DOCUMENT RESUME

ED 162 903 SE 025 440

TITLE	Aviation Futures to the Year 2000.
INSTITUTION	Futures Group, Glastonbury, Conn.; Urban Systems Research and Engineering, Inc., Cambridge, Mass.
SPONS AGENCY	Federal Aviation Administration (DOT), Washington, D.C.
PUB DATE	Feb 77
NOTE	109p.; Occasional shaded charts and graphs may not reproduce well
EDRS PRICE	MF-$0.83 HC-$6.01 Plus Postage.
DESCRIPTORS	*Aerospace Industry; Aviation Technology; *Economics; Fuel Consumption; *Futures (of Society); Prediction; Science Education; Simulation; Socioeconomic Influences; *Transportation; *Trend Analysis

ABSTRACT

This document describes five alternative scenarios which present various conditions that may exist in the United States from now to the year 2000, and which would be important in shaping demand for air transportation. Each scenario describes the potential evolution of various socioeconomic conditions, along with a projection of the amount and type of air transportation likely to exist under those conditions. The key variables that come into play in the scenarios are the gross national product, population, business productivity, the unemployment rate, the cost of domestic crude oil, operations at towered airports, enplaned passengers, total revenue passenger miles, air cargo, and jet fuel consumption. The five scenarios used in the study are the limited growth scenario, the expansive growth scenario, individual affluence, muddling through, and the resource allocation scenarios. (Author/EB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

aviation futures
TO THE YEAR 2000

?

SE 025 440 ED162903

2

3

ACKNOWLEDGMENT

The alternative future scenarios summarized in this report and the methodology used to prepare them were developed for the Federal Aviation Administration by The Futures Group of Glastonbury, Connecticut, with assistance from Urban Systems Research and Engineering, Inc. of Cambridge, Massachusetts.

PURPOSE OF REPORT

This report was developed to promote understanding of and discussion on the range of future conditions within which the National Aviation System may have to operate. For this reason the scenarios, findings and conclusions presented in this report, while meant to represent plausible alternatives, do not necessarily reflect the official views of the Federal Aviation Administration.

FEBRUARY 1977

CONTENTS

	Page
Preface	1
Introduction	2
Executive Summary	3
Major Findings	10
Issues	17
Uncertainties	22
The "Scenario" As An Analytical Tool	26
Limited Growth Scenario	28
Socioeconomic Conditions	
Air Transportation	
Muddling Through Scenario	33
Socioeconomic Conditions	
Air Transportation	
Resource Allocation Scenario	38
Socioeconomic Conditions	
Air Transportation	
Individual Affluence Scenario	44
Socioeconomic Conditions	
Air Transportation	
Expansive Growth Scenario	49
Socioeconomic Conditions	
Air Transportation	
Approach	55

PREFACE

This is a study of potential future environments for the National Aviation System. The study was directed at constructing five alternative scenarios describing various conditions which may exist in the United States from now to the year 2000, and which would be important in shaping demand for air transportation. Each scenario describes the potential evolution of various socioeconomic conditions, along with a projection of the amount and type of air transportation likely to exist under those conditions.

These scenarios are **not** intended as forecasts of future conditions. Rather they were constructed in an attempt to describe a range of plausible conditions important to the future of air transportation so that those involved with designing and assessing aviation system policies might have a framework for policy analysis and synthesis.

Data available at the time the scenarios were being developed were used in the calculation of trends and levels of change in the economic indices. Therefore all data after 1973 are estimates rather than actual figures.

The National Aviation System (NAS) is an aggregate embracing all the people, facilities, equipment, regulations and procedures involved in the provision of air transportation services. Thus it includes military aviation when it enters the civil system. In those few instances where the term includes aviation manufacturers, the context provides clear indication of that intention.

This document presents:

1. The purpose in conducting the study;

2. The major findings, in terms of significant trends and preliminary conclusions, that result from looking at the future of aviation in this manner;

3. Key issues highlighted by the study;

4. Uncertainties to be explored to verify preliminary conclusions, to clarify the nature and timing of apparent problems, and to complement the content of the scenarios;

5. The substantive highlights of each scenario. These data describe both the socioeconomic conditions of each world and the National Aviation System that might evolve under those conditions; and

6. The major steps employed to construct the scenarios and accomplish the various supporting analyses.

The scope of the first effort was limited almost exclusively to the United States. Very little attention is devoted to international political, social and economic conditions or to the evolution of international aviation under those conditions. The methodology is sufficiently flexible, however, to permit similar future studies to take a global perspective.

INTRODUCTION

In the past, growth in air transportation was largely determined by capabilities in aviation system technology. However, recent developments have indicated that future aviation system developments will be influenced also, and with significant force, by concern for environmental impacts, social legislation and economic developments, and with changing attitudes about lifestyle, both here and abroad. The system congestion of the late 1960's; the twin terrors of hijacking and bombing; legislation to ensure that the elderly and handicapped have equal and safe access to public transportation; the reactions of noise-impacted neighbors of our airports; all of these developments provide convincing arguments that it is no longer sufficient to plan in terms of simple "projections of demand," nor to base projections largely on desires to exploit technological advancements in the area of air transportation. Indeed, events of recent years suggest that socioeconomic change may, for the foreseeable future, be more dynamic than technological change.

The decision within the Federal Aviation Administration to explore the available means to look into the future of aviation was fostered by the recognition that in most of the aforementioned developments, and others, the agency and the aviation system were responding after the fact, a posture that is usually costly and always uncomfortable. The decision having been made, a question immediately arose—"What future should we look at?" It was obvious that the future could follow many paths, accordingly the study was directed at:

1. Depicting a plausible range of future socioeconomic conditions, or scenarios, to the year 2000 which are likely to be important to the future demand for air transportation and the ways in which that demand will be met.
2. Describing alternative evolutions of the aviation system in America which are likely to be logical outcomes of those conditions.

The purpose of taking this approach was to improve the design and assessment of aviation system policy by acquiring the capability to:

1. Judge the ability of current policy to adequately address alternative future needs (i.e., evaluate the potential for policies to be effective in many potential future worlds).
2. Determine ways in which current policy might best be modified to treat potential future conditions.
3. Anticipate the types of future policies which appear promising and under which conditions they would be so.
4. Monitor conditions as they unfold, then assess which of the alternatives depicted are becoming more (or less) likely, and adjust policies accordingly.

The first results and the study approach are described in the following chapters. We are publishing these early results in order to tap the expertise that you and your colleagues have acquired through your involvement in aviation. As you read, you will find more questions than answers. Note your questions as you go and your comments as well, and send them to us at the address printed below. In this way you can help us to ask better questions so that, together, we can start developing better answers to the problems that lie ahead for aviation.

Send comments and questions to:

Federal Aviation Administration

Aviation Futures (AVP–110)

800 Independence Ave., S.W.

Washington, D.C. 20591

EXECUTIVE SUMMARY

Purpose

Recent events show that many forces besides technology will govern future aviation development. The energy crisis, environmental concerns, the rise of terrorism, and unprecedented peacetime inflation are examples of these new factors, which have had profound effects on aviation in the recent past. "What next?" is an often repeated question of our time.

Believing that only a few new phenomena are true surprises, FAA undertook this study to see what might be in store both for itself and the aviation community in the last quarter of the century and to develop a systematic, repeatable method of conducting this broad planning function. The study achieved both objectives. The following sections summarize the findings and conclusions and describe the approach.

FINDINGS AND CONCLUSIONS

FAA Concerns

Airspace Capacity. The upgraded third generation air traffic control system will be a necessity at all large and medium hubs, and, near the end of the century, a fourth generation system may be essential as well. These conclusions hold as long as FAA continues its traditional policy of serving all airspace users when they want to use the system, and when the economy maintains at least moderate real growth.

Airport Capacity. Major additions to airport capacity including some major new air carrier airports and a considerable number of new general aviation airports will be essential. This finding is valid if FAA continues its traditional airspace use policy and the economy grows at least moderately in real terms. With very high real economic growth, a few large all-cargo airports could be in operation by the year 2000.

Aviation Safety. Aviation will continue to have low accident and fatality rates compared to activity levels, but more accidents and fatalities will occur per unit of time under moderate to high growth conditions.

Aircraft Noise. Unless all air carrier aircraft meet the noise standards of FAR Part 36 by the early 1980's, aircraft noise will continue to be a constraint on the growth of the air transportation system. Newer aircraft entering the fleet beyond 1980 will be required to meet more stringent standards, but their impact on reducing overall noise exposure around airports will not be realized until the 1990's.

Aviation Energy Consumption. Use of aircraft burning a non-petroleum fuel is highly unlikely. However, improvements in technology will make aircraft engines more fuel efficient, and the availability of alternative energy sources for non-transportation use will make petroleum more available to aviation. With moderate to high real economic growth, jet fuel consumption in 2000 could be 1.5 to 4.5 times higher than today.

FAA Institutional Role. A renewed societal emphasis on free enterprise and a concomitant policy of ending Federal operating programs could result in the transfer of the air traffic control function to a quasi-governmental corporation.

Aviation Industry

Revenue Passenger Miles in the year 2000 will total 168–605 billion compared to 131 billion in Fiscal Year 1974.

Revenue Passenger Enplanements in 2000 will total from 272.0 million to over 1 billion compared to 208 million in 1975.

Cargo Revenue Ton Miles will grow at least 6 percent per year for the remainder of the century.

Total Itinerant Aircraft Operations in 2000 will total 52–322 million compared to 59 million in FY 1975.

Aircraft In Service. Unconventional aircraft such as lighter-than-air aircraft will not be introduced. However, with moderate to high economic growth new conventional aircraft such as a 1000 passenger transport and 150 passenger jet STOL will form a small percentage of the air carrier fleet by the end of the century.

METHODOLOGY

A documented repeatable systematic methodology was used in preparation of this study. In this approach, a plausible range of future values is forecast for a core set of socioeconomic variables. A range of future values is forecast for other socioeconomic variables given the projected values of the core set and the likely impacts of future events. The alternative forecasts of the socioeconomic variables are divided into mutually consistent groups and narrative descriptions are prepared to form scenarios, which quantitatively and qualitatively describe a plausible range of alternative futures. Aviation activity forecasts are then developed with systematic application of judgment and partially checked with a computerized model.

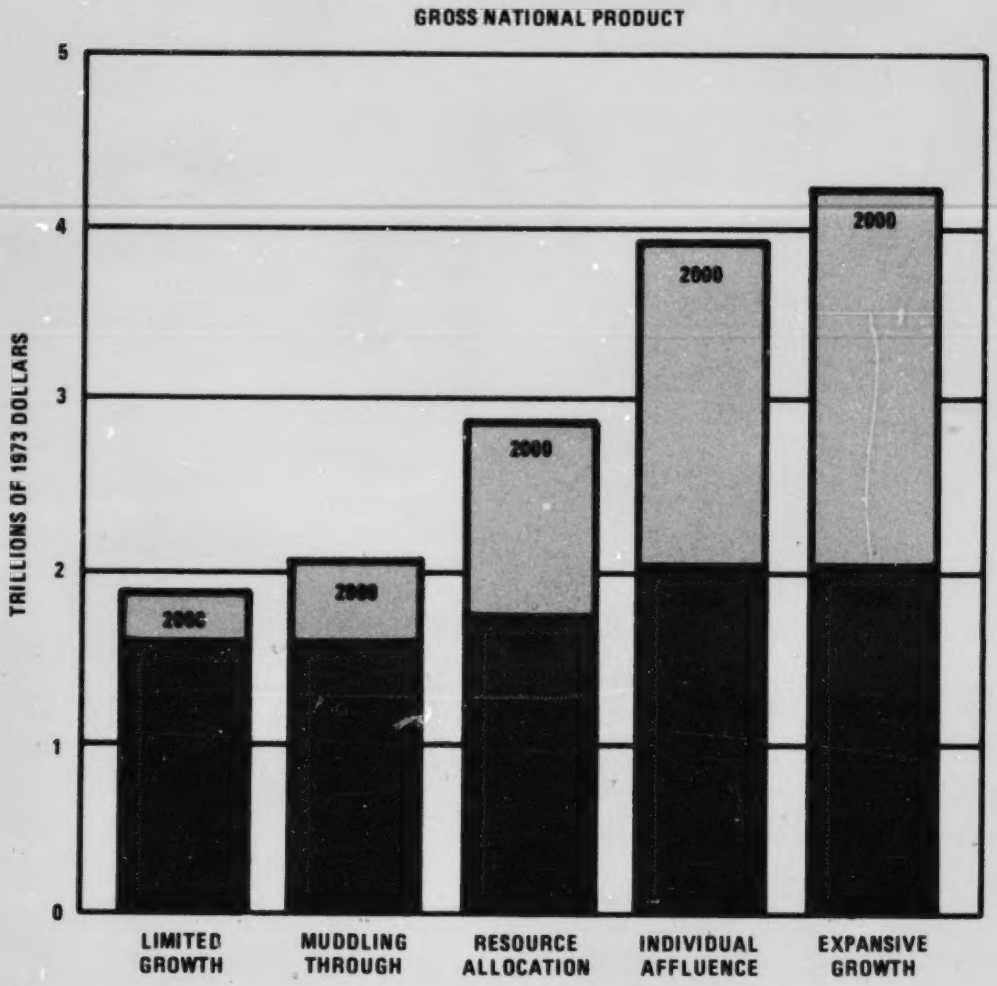
Five scenarios were used in this study: Limited Growth in which the Federal Government on behalf of an environmentally conscious society adopts a limited growth policy consistent with low population and GNP growth; Expansive Growth in which a return of the free enterprise ethic and technology create unprecedented prosperity characterized by high growth in both GNP and population; Individual Affluence also a highly prosperous future but a world of very strong Federal regulation reflected in high GNP growth with low population growth; Muddling Through a future marked by continued recession, inflation and uncertainty accompanied by low GNP but high population growth and Resource Allocation a future in which many of today's pressing problems are resolved but prosperity is less than in Individual Affluence or Expansive Growth. This scenario combines moderate GNP growth with low population growth.

The following charts summarize the five scenarios in terms of the key variables and describe the range of the alternative futures by comparing selected variables.

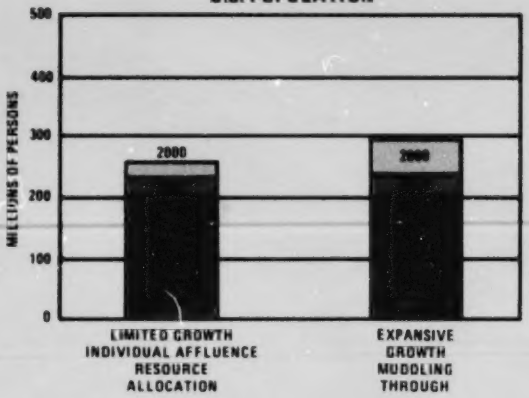
COMPARISON OF PRESENT AND YEAR 2000 LEVELS OF KEY VARIABLES FOR THE FIVE SCENARIOS

KEY VARIABLES	1974	LIMITED GROWTH	MUDDLING THROUGH	RESOURCE ALLOCATION	INDIVIDUAL AFFLUENCE	EXPANSIVE GROWTH
GROSS NATIONAL PRODUCT						
– TRILLIONS OF 1973 DOLLARS	1.3	1.9	2.1	2.9	4.1	4.3
POPULATION						
– MILLIONS OF PEOPLE	212	250	297	250	250	297
BUSINESS PRODUCTIVITY						
– OUTPUT/MAN-HOURS INDEX (1973 DOLLARS)	112	168	161	250	408	354
UNEMPLOYMENT RATE						
– PERCENT	5.6	6.1	8.6	4.8	4.4	5.0
COST OF DOMESTIC CRUDE OIL/BARREL AT THE WELL						
– 1973 DOLLARS	11.0	8.5	14.0	8.0	6.0	7.5
OPERATIONS AT TOWERED AIRPORTS (MILLIONS)						
– AIR CARRIER	12	17	10	17	25	46
– GENERAL AVIATION	43	37	39	105	154	283
– TOTAL OPERATIONS[1]	57	115	52	125	182	333
ENPLANED PASSENGERS						
– MILLIONS	207	406	272	471	788	1,113
TOTAL REVENUE PASSENGER MILES (BILLIONS/YEAR)	131	259	167	304	485	597
AIR CARGO–TOTAL REVENUE TON MILES (BILLIONS OF TON MILES)	3.2	8.3	3.8	9	35	65
JET FUEL CONSUMPTION						
– AIR CARRIER AND GENERAL AVIATION (MILLIONS OF BARRELS)	190	317	158	317	517	850

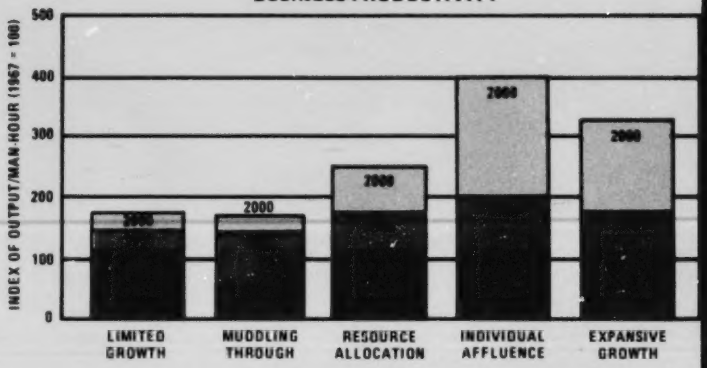
[1] Total Includes Military


GROSS NATIONAL PRODUCT
TRILLIONS OF 1973 DOLLARS
5
4
3
2
1
0
2000
2000
2000
2000
2000
LIMITED GROWTH
MUDDLING THROUGH
RESOURCE ALLOCATION
INDIVIDUAL AFFLUENCE
EXPANSIVE GROWTH

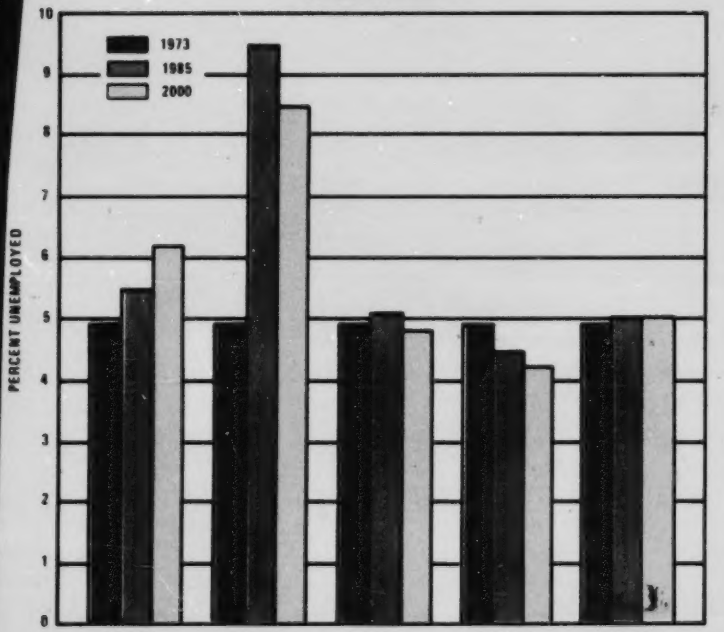
U.S. POPULATION



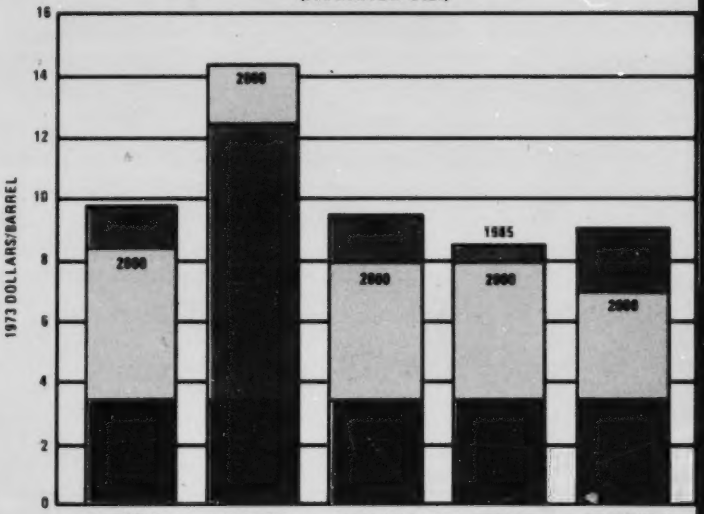
BUSINESS PRODUCTIVITY

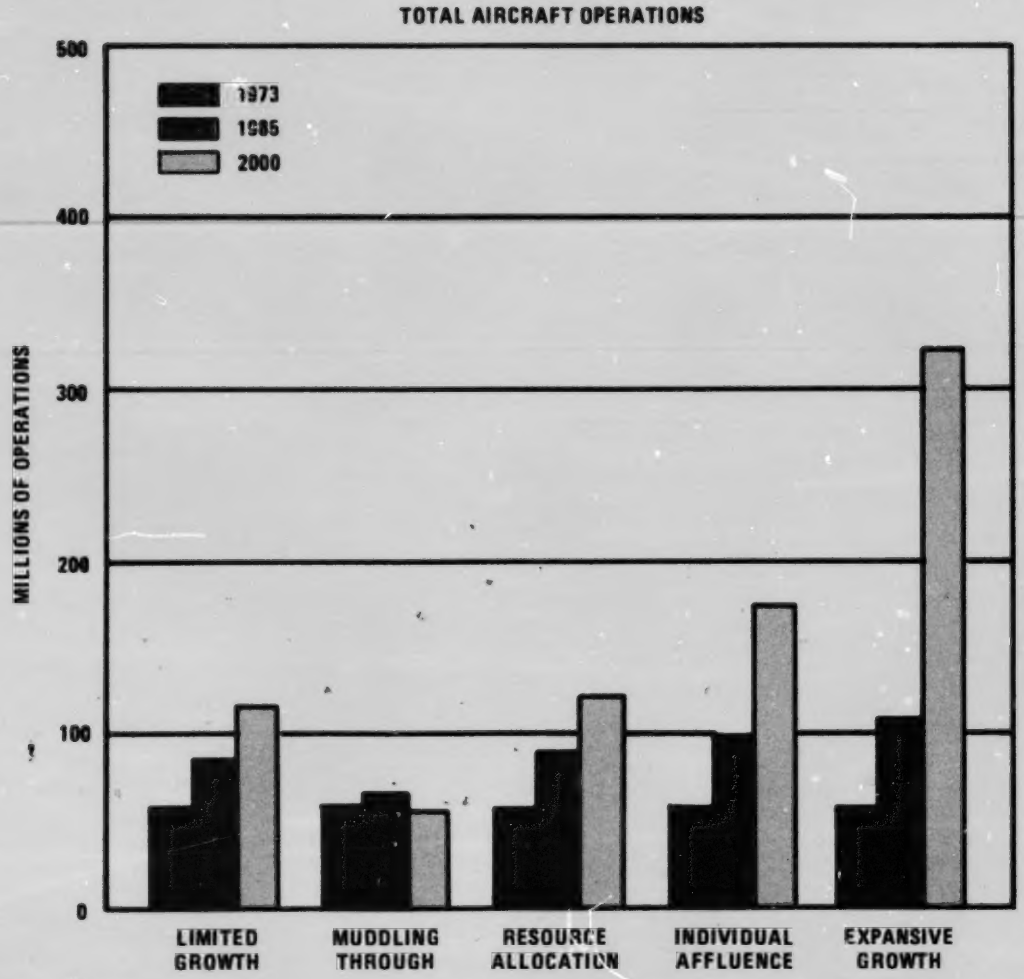


UNEMPLOYMENT

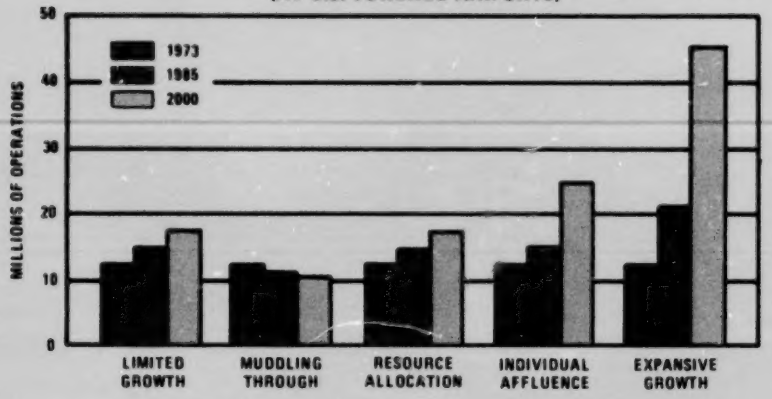


WELL HEAD PRICE OF CRUDE OIL (AVERAGE U.S.)

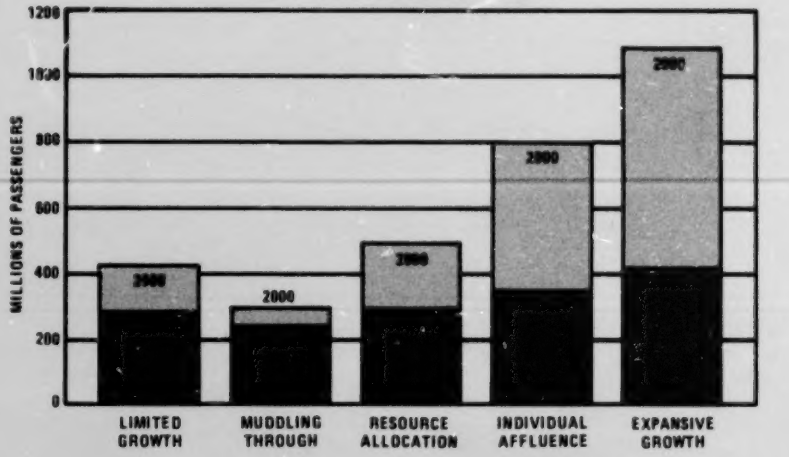



TOTAL AIRCRAFT OPERATIONS
1973
1985
2000
500
400
300
200
100
0
MILLIONS OF OPERATIONS
LIMITED GROWTH
MUDDLING THROUGH
RESOURCE ALLOCATION
INDIVIDUAL AFFLUENCE
EXPANSIVE GROWTH

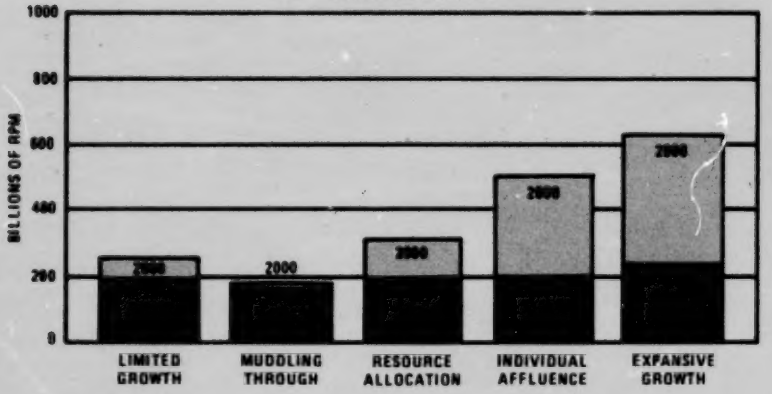
TOTAL AIR CARRIER OPERATIONS (AT U.S. TOWERED AIRPORTS)



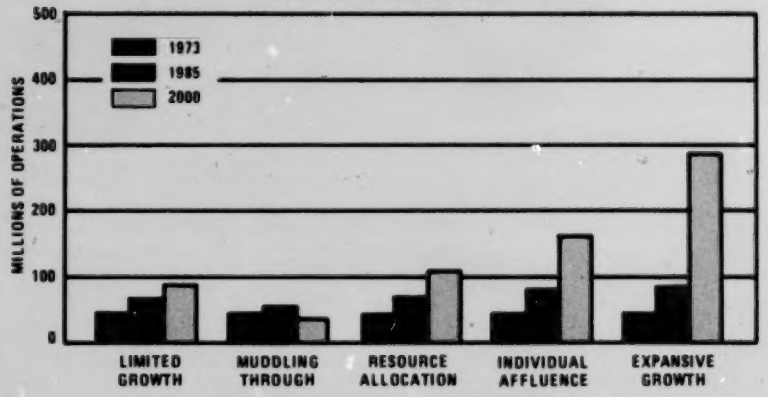
TOTAL ENPLANED PASSENGERS (AT U.S. TOWERED AIRPORTS)



TOTAL REVENUE PASSENGER MILES (DOMESTIC U.S.)



TOTAL GENERAL AVIATION OPERATIONS (AT U.S. TOWERED AIRPORTS)



MAJOR FINDINGS

Air Carrier Trends

General Aviation Trends

Fuel

Technology

Complementary and Competing Modes

Air Cargo

Aviation Safety

SUMMARY OF MAJOR FINDINGS* BY SCENARIO

	AIR CARRIER TRENDS	GENERAL AVIATION TRENDS	FUEL CONSUMPTION	AIRCRAFT TECHNOLOGY
LIMITED GROWTH	• Small increase in operations. • No new aircraft introduced. • Enplaned passengers increased from 208 million (1975) to 406 million.	• From 72% (1970) to 84% of operations at towered airports. • 95% plus of total aircraft.	• Jet: 65% increase to 317 million bbls/yr. • Avgas: 115% increase to 27 million bbls/yr.	• Low R&D activity except for fuel efficiency. • Stretched versions of existing aircraft.
MUDDLING THROUGH	• Decline in operations. • High load factors. • Enplaned passengers increased from 208 million (1975) to 272 million.	• From 72% (1970) to 75% of operations at towered airports. • Decline in GA ops by 4 million.	• Jet: 17% *decrease* to 158 million bbls/yr. • Avgas: 23% *decrease* to 10 million bbls/yr.	• Low R&D activity. • Only minor changes in existing types of aircraft.
RESOURCE ALLOCATION	• Small increase in operations. • Enplaned passengers increased from 208 million (1975) to one-half billion.	• From 72% (1970) to 84% of operations at towered airports. • 95% plus of total aircraft.	• Jet: 65% increase to 317 million bbls/yr. • Avgas: 115% increase to 28 million bbls/yr.	• Moderate R&D activity, concentrating on fuel efficiency and noise reduction.
INDIVIDUAL AFFLUENCE	• 100% increase in operations. • Enplaned passengers increased from 208 million (1975) to 800 million. • STOL and Super turbojets.	• From 72% (1970) to 85% of operations at towered airports. • 95% plus of total aircraft.	• Jet: 169% increase to 517 million bbls/yr. • Avgas: 154% increase to 33 million bbls/yr.	• High levels of technology tempered by environmental concerns. • Fewer new aircraft than Scenario 5
EXPANSIVE GROWTH	• 300% increase in operations. • Enplaned passengers increased from 208 million (1975) to 1 billion. • Jet STOL, Super large, and SST aircraft.	• From 72% (1970) to 85% of operations at towered airports. • 95% plus of total aircraft.	• Jet: 342% increase to 850 million bbls/yr. • Avgas: 423% increase to 68 million bbls/yr.	• Rapid development of new aircraft. • Heavy emphasis on R&D.

*Unless otherwise stated all figures shown are for the year 2000.

SUMMARY OF MAJOR FINDINGS* BY SCENARIO

	AIR TRAFFIC CONTROL TECHNOLOGY	COMPLEMENTARY AND COMPETING MODES	AIR CARGO	AVIATION SAFETY
LIMITED GROWTH	• UG3rd installation began in 1985. • NAS rate of growth reduced.	• Auto intercity travel declines. • Shift from auto divided between air, rail and mass transit.	• Low growth (less than 3%) due to weak economic conditions.	• Relatively low demand. • Decline in rates and number of accidents.
MUDDLING THROUGH	• Little change in NAS from 1970's.	• Increased telecommunications substituted for travel.	• Low growth (+2%) then decline due to economic conditions.	• Demand less than system capacity, resulting in • Fewer accidents.
RESOURCE ALLOCATION	• UG3rd in 1985. • 4th generation ground-based ATCS by 2000.	• Auto intercity travel declines. • High speed ground intercity transit.	• Moderate growth (+4%).	• Relatively low rate of increase in demand, and • Increased use of technology in NAS, results in, • Decline in rates and number of accidents.
INDIVIDUAL AFFLUENCE	• UG3rd by 1980. • 4th generation ground-based ATCS by 1990.	• Auto retains major role. • High speed ground intercity transit.	• High growth (+9%). • All-cargo flights increased.	• Technological and procedural advances, but • No decline in numbers of accidents, because of • Heavy increase in aviation activity.
EXPANSIVE GROWTH	• Automated air-based ATCS by 1990.	• Auto retains major role. • High speed ground intercity transit.	• Very high growth (+12%). • All cargo airports in 1990's.	• Improved technology and operating procedures. • Number of accidents and fatalities do not decline because of high demand.

*Unless otherwise stated all figures shown are for the year 2000.

Air Carrier Trends

The number of air carrier operations at airports with FAA control towers reflects the level of air passenger demand and the types of aircraft in use. These factors, in turn, are influenced by general economic conditions and activities. Thus, the trend of air carrier growth has been closely correlated with the growth in GNP and population.

The future trends of air carrier operations will continue to be influenced by socioeconomic conditions. However, recent developments indicate that in the future, air carrier operations may also be affected to a large extent by concern for environmental effects, subsidies from government for competing modes in short-haul markets, and other governmental policies aimed at fuel conservation and efficiency.

Presented below are the conclusions that have been drawn from the study on future air carrier trends.

Air Carrier Activity Demand: Under the two extreme future economic conditions, high and low growth, the number of enplaned passengers is expected to grow from 1975 to 2000 at annual rates ranging from .9 percent to 6.7 percent. Compared to the 1975 total of 208 million passengers, these growth rates to 2000 would range from 271 million passengers under difficult economic conditions to more than 1.1 billion passengers under expansive economic conditions. The corresponding changes in air carrier operations (takeoff or landing) at towered airports would likely range from an average anuual rate of −.9 percent to 5.2 percent. Compared to the 1975 level of 12.8 million air carrier operations, these rates would result in from 10 million operations to 46 million operations in the year 2000.

The negative growth rate under low-growth conditions reflects several causes. As economic conditions deteriorate, reflecting fuel and material shortages, disposable income declines and at the same time airline operating costs and other prices would be rising. In addition, regulations in the interest of fuel conservation and air carrier profits would likely impose more restrictions on air carrier activities. As a result, airline load factors would be expected to rise at the expense of service levels and frequency of flights with virtually no new aircraft introduction.

New Aircraft: Under steady and growing economic conditions where GNP and GNP per capita are expected to grow at annual rates of 2.4 percent or higher, new aircraft such as STOL and super wide-body aircraft are anticipated to be introduced sometime after 1985. These aircraft would meet special needs of various markets and thus be more economical to operate. However, only with high growth is the SST expected to enter the domestic fleet.

Stage Length: Air carriers are anticipated to serve as the dominant long-haul travel mode undeterred by any modal competition. For the short-haul markets, however, high speed ground transportation (HSGT) modes are anticipated to serve competitively. The relatively fuel efficient HSGT are expected to be developed especially in densely populated and industrialized corridors, due to growing environmental concerns and conscious fuel conservation efforts. As a result, the average stage length of air travelers is expected to increase while short-haul markets would be gradually penetrated by HSGT.

General Aviation Trends

General aviation is now and will continue to be a major operational component of the aviation community. This statement holds regardless of a wide range of socioeconomic conditions and governmental policies.

The GA Fleet: General aviation aircraft constitute 98 percent of all aircraft in use today and, in FY 1975, 98 percent of civil aircraft produced were for general aviation. In all socioeconomic conditions considered

the GA fleet will continue to represent over 95 percent of all active aircraft and the general aviation aircraft produced will remain above 90 percent of total civil aircraft production.

GA Operations: In the operations area, GA presently accounts for 75 percent of total operations at FAA towered airports. Even with pessimistic future socioeconomic conditions GA is forecast to remain at this level. In favorable economic conditions, GA grows to where it accounts for between 83 and 85 percent of all tower operations.

All forecasts call for increasing sophistication in GA avionics and this will result in a situation where general aviation will comprise over 50 percent of all instrument operations as opposed to the present level of 41 percent. This percentage could be greater than 50 percent if navigation systems develop that would permit instrument operations at airports without the necessity for major capital investment at the particular location, i.e., some form of global positioning system.

To summarize, general aviation will be the major FAA workload factor and the primary factor in system expansion throughout the remainder of twentieth century.

Fuel

The future trends of fuel availability and corresponding fuel prices are expected to be among the major determinants of aviation activity and growth patterns. Crude oil price projections for 2000 (in 1973 dollars) range from $6 per barrel in a very optimistic economy to $14 per barrel in a very slow economy. The range of price levels reflects the degree and extent to which the nation would achieve energy self-sufficiency by technological innovations and energy conservation efforts.

Major energy technological breakthroughs are not anticipated before 1985. The energy situations assumed correlate closely with levels and growth patterns of GNP and other socioeconomic variables, and thus projected National Aviation System activity.

For the next 25 years, all aircraft are expected to burn petroleum based jet fuel and aviation gas with no apparent substitute fuel such as hydrogen.

The total amount of aviation fuel consumption would reach over 900 million barrels for the expansive economy, while fuel consumption is expected to decline in the low growth economy where the number of air carrier operations would decline as a result of the high price of oil and governmental regulations aimed at increasing the aviation system load factors to reduce flight frequency.

Due to environmental concerns and energy saving efforts, existing aircraft engines are anticipated to be improved for fuel efficiency and noise reduction. It is also expected that airlines will operate more economically by serving specific market areas with especially suited and cost-efficient aircraft.

As a result of fuel conservation efforts, the trend will be toward more investments in relatively fuel efficient short-haul ground transportation systems in densely populated major transportation corridors.

In the long run, the prospect of petroleum supply, and fuel prices domestic or imported, cannot be viewed with certainty. Fuel consumption patterns, coal liquefaction technology, energy R&D, and fuel conservation efforts in the future will have great influence in shaping and determining the growth pattern and economic structure of the aviation industry and communities.

Technology

In the two very affluent scenarios, technology solves the energy crisis with the following developments: solar energy, gasification of coal at the mine, geothermal energy and production of oil from shale. These advances cause an actual decline in the price of crude oil and make the supply of jet fuel and aviation gasoline large enough to satisfy enormous growth in demand for air transportation. These two affluent scenarios also include the introduction of advanced air traffic control systems—air based air traffic control under Expansive Growth and a fourth generation, ground-based system under Individual Affluence. This implies that high sustained economic growth will accelerate the present trends of revolutionary increases in data processing system performance and decreases in system cost and hasten the application of this advanced technology to aviation. Under Expansive Growth, an SST and a 1,000 passenger transport constitute small percentages of the air carrier fleet by 2000, and a new 150 passenger jet STOL accounts for over 10 percent.

Under Individual Affluence, the extra-large transport and jet STOL form small percentages of the fleet by 2000. Thus, the ability to produce abundant conventional aviation fuel at moderate prices would appear to cause abandonment of current attempts to develop unconventional aircraft such as lighter-than-air vehicles and new types of rotorcraft.

Technology has a much weaker effect on aviation in the Muddling Through and Limited Growth Scenarios. Neither scenario includes new models of conventional aircraft or unconventional aircraft systems.

The Limited Growth Scenario includes the full upgraded third generation air traffic control system after 1985, and Muddling Through has some elements of that system. Both these scenarios envision more substitution of telecommunications for air travel. This implies that changes in societal values in favor of environmental preservation and/or economic security would create an increasingly favorable climate for developments in computer and video communications now being used experimentally.

Complementary and Competing Modes

The degree to which the automobile has dominated domestic travel may be challenged, but aviation would not necessarily benefit in proportion to the decline in growth of automotive travel. In the Limited Growth scenario, automobile ridership declines because of high gasoline cost and greatly reduced highway construction. Also the decreasing size of the automobile limits its comfort for intercity travel. However, lost automobile ridership is diverted to public mass transit and intercity rail transportation as well as aviation. The Resource Allocation scenario also includes decreased use of the automobile and diversion of some passengers to intra-corridor high speed ground transportation. In the Muddling Through scenario, telecommunications substitutes for many trips. The relative position of the automobile in the two affluent scenarios is no worse than it is today, perhaps even better, especially following introduction of the electric automobile in the late 1990's. The implication here is that a return to high, real, sustained, economic growth will be required to preserve the automobile's traditional dominance of American passenger transportation. Otherwise the present trends adversely affecting the relative position of automoble travel—decreased comfort, increased costs, and decreased average trip speed—will continue.

A new high-speed ground mode would compete with aviation under conditions of sustained moderate to high economic growth. This development is envisioned in the Resource Allocation, Individual Affluence, and Expansive Growth scenarios.

High fuel prices and government subsidization would strengthen conventional intercity rail travel vis-a'-vis aviation in the Limited Growth and Muddling Through scenarios.

Airport access is very likely to be enhanced with further development of urban transit systems or as an offshoot of unconventional high-speed ground transportation.

A passenger's trip may well be facilitated through development of intermodal ticketing and remote air passenger terminals.

Air Cargo

Air cargo will still be second in importance to passenger transportation at the turn of the century. Under Expansive Growth, air cargo in 2000 would be 20–25 times greater by weight than today, but over half of it would still be carried on passenger flights. In the other scenarios, the year 2000 proportion of air freight carried on passenger flights would range from 65–85 percent compared with about 75 percent today.

Under any but the worst foreseeable economic conditions, air cargo will experience substantial growth for the remainder of the century. The annual increase in revenue ton-miles will not be less than 6 percent and the minimum annual growth in air cargo tonnage should be less than 4 percent.

By the end of the century, shippers probably will no longer consider the price of air cargo and the lack of immediately available space to be burdensome. The cost of air shipments will be at least 16 percent higher than today, but the increases in the proportion of perishable and exotic commodities to the total of freight carried will give air freight a greater competitive advantage than it has today. The very high growth in scheduled passenger service will provide plenty of additional space for ordinary air cargo and significantly more all-cargo flights should provide space for carriage of very heavy outsized freight.

By the turn of the century, a small number of all-cargo airports could be in operation. With high sustained real economic growth, the growth in air cargo could be so great that air cargo will contribute significantly to both airside and landside congestion at major hub airports. This condition would cause development of the necessary political support for a shift of all-cargo flights to totally new airports or abandoned military airfields in outlying areas. In size, these airfields would be comparable to today's large air carrier airports. In addition, these airports would have truck terminal and access facilities of unprecedented scale and sophistication; including access highways built at least to present interstate standards, a sophisticated truck dispatching system, a complex truck routing system within the airport perimeter, and advanced means of security checks.

Aviation Safety

During the years 1970–1974, the United States aviation system averaged 247 air carrier fatalities per year, 49 air carrier accidents, and 4,472 general aviation accidents. In the year 2000 with no improvements in the respective rates, the potential growth in aviation activity could result in from 300 to 700 air carrier fatalities, with 60 to 160 air carrier accidents and from 10,000 to 30,000 general aviation accidents. The exception to this pattern, of course, would occur under declining economic conditions, when aviation activity would also decline.

These potential impacts of growth suggest that FAA programs in safety research, education, and regulation will have to be increased in order to sustain the long-term decline in accident rates.

ISSUES

FAA Productivity

Capacity

Safety

Noise

SUMMARY OF ISSUES BY SCENARIO
Relative Impacts on the National Aviation System

ISSUES \ SCENARIOS	LIMITED GROWTH	MUDDLING THROUGH	RESOURCE ALLOCATION	INDIVIDUAL AFFLUENCE	EXPANSIVE GROWTH
FAA PRODUCTIVITY	•	•	○	●	●
AIRPORT CAPACITY	○	•	●	●	●
AVIATION SAFETY	•	•	○	●	●
AIRCRAFT NOISE	○	•	●	○	○

KEY
● – Major potential impact.
○ – Moderate potential impact.
• – Minor or no potential impact.

FAA PRODUCTIVITY

The Federal Aviation Administration has as its prime responsibilities the regulation of air commerce to promote its development and safety, and the operation of the air traffic control system in a manner consistent with those objectives. In meeting its statutory responsibilities the agency has a parallel concern that its activities be conducted so as to use the resources provided to it in an efficient manner. One measure of efficient resource utilization is the number of employees (input) needed to provide a given level of service (output); e.g., annual aircraft handled, instrument operations, flight services provided. In comparing these input-output indices we find that while the output (aviation activity) increased at an annual rate of eight percent over the last decade, FAA staffing only increased at an annual rate of three percent. This increase in work force efficiency or productivity is largely attributable to the impact of increased technology in air traffic control.

The scenarios depict a broad range of aviation activity in the future. Since only the bottom of the range envisions a decline in activity, it is apparent that from present perceptions the realm of plausibility has a strong bias toward growth. At the hazard of oversimplification, we could say that growth in the middle ranges presents a relatively straightforward challenge. It is largely a matter of numbers, more aircraft and more activity. And the answer would seem about as straightforward—provide more efficient tools for the people operating the system. High rates of growth however, present a more complex challenge. The numbers are even bigger, and the variety of aircraft with differing operational requirements increases with the more rapid pace of technological advance. Thus, to keep the air traffic control system and the airports abreast of the numbers and technology of civil aircraft, the tools will have to be both more efficient and more sophisticated, perhaps even to the point of requiring a totally different concept of air traffic control.

Thus, the challenges of growth over the next 25 years will require very careful planning with a total-system perspective. The amounts of money and numbers of people involved will be very large, and therefore, the cost of error will be high. It will be difficult just to gain an accurate assessment of needs and to develop effective, optimizing decision criteria to ensure that the air traffic control system complements aviation demand in both size and sophistication and to determine the efficient input mix of people and technology. However, given that capability, decisions will still be hard to make and implement because of a number of changing factors.

1. There is no evidence in any of the future scenarios that future contions will retard the current trends that are increasing the accountability and visibility of the Federal manager. These trends are discernible in the increasing frequency and effectiveness of private-citizen and interest-group participation in public decision making and public program review. Among the factors involved are: the spread of modern decision theory; availability of high-powered computing devices; and the work of large professional staffs in such public interest organizations as Common Cause, and the various consumer environment and conservation groups. Of primary importance are the modern news media, which can turn any event into a national concern in a matter of hours. Thus, we can expect that the decision process in the future will involve more special-interest views and the review and oversight function will be practiced by an increasing number of diverse interests. This will protract and complicate the process and add another challenge to the decision maker—to find a way to come out of the process with a coherent sense of direction.

2. The elements of investment decisions are changing. In recent decades, inflation has had its heaviest impact on current operating costs through salaries and related benefits. Thus, technology was seen to offer, among other advantages, more stable operating costs over time. However, the energy crisis is changing the formula, making energy cost a stronger and more volatile factor. This implies that new trade-offs will have to be examined and perhaps new arguments will have to be developed to counter the traditional rules-of-thumb applied to Federal budget requests.

In summary, it appears that, with continued growth, the road to increasing productivity is going to be difficult to find and equally difficult to travel.

CAPACITY

The basic issue of aviation system capacity is related to the demand for terminal services. The en route sector of the NAS should impose minimum restrictions on aviation growth regardless of socioeconomic conditions. This does not imply that high growth rates will not create en route capacity problems. It does indicate that the problems are seen to be solvable in a cost/effective range.

Terminal Airside Capacity Problems: The demand for terminal capacity developments under varying scenarios presents a very complex picture. If times are tough, in the mid-1930's sense, there would be excess capacity throughout the system by 1985. This would involve the problem of reducing expenditures and service in a manner that best meets the reduced demand.

At the other end of the economic spectrum, aviation could be faced with a demand which would strain the most expansive of economic environments. Under these most optimistic conditions the NAS would require numerous major airports, fourth generation ATC system implementation, large STOL aircraft and the supporting terminal facilities, one thousand passenger air carrier transport and a scheduling system that would minimize peak-hour problems at airports while ensuring high load factors per aircraft.

The high and low extremes of demand bring sharp focus on the basic terminal capacity issue. This is the question of the extent to which the system should respond to demand. Response can range from:

a. Attempting to meet all demand;

b. Meeting demand within a selected benefit/cost or cost-effective range, or

c. Setting an arbitrary limit on demand response.

The last item (c) above could involve the establishment of policies to discourage or redistribute demand. This could include the imposition of absolute quotas or the exclusion of selected classes of aircraft or categories of aviation.

Still, noise has resulted in airport curfews and, as a result, some airports lie unused for one-third of the available time, while the system lacks airport capacity and suffers from severe peaking problems. Many aircraft in use today exceed FAR 36 standards and the question of noise retrofit is unanswered. In acquiring land for new airports or expansion of existing airports additional acreage is required for noise buffer purposes and acreage is dollars.

The aviation community must do something to control noise at the source and ensure that adverse noise levels are contained within certain land areas if aviation is to meet future demand.

Unused Capacity: Another issue involved with capacity is the development of techniques to utilize existing capacity. Some of our major hubs that contribute heavily to national delay have an unused capacity from 10:00 p.m. to 6:00 a.m. These empty runways and empty air carrier seats are not available to relieve our pressing capacity problems.

SAFETY

Two major safety issues face aviation for the duration of the century:

Will safety standards of general aviation approach those now followed by air carriers?

Will measures be taken to increase the probability of passenger and flight crew survival of a crash?

Aviation will continue to be a safe transportation mode. Fatality and accident rates will remain low, but the growth in activity will force up fatalities and accidents to much higher levels unless stronger or additional safety programs are instituted and research provides ways to focus on and resolve persistent causes. Studies show that many air carrier fatalities could be prevented if aircraft interiors were less flammable and if aircraft were easier to evacuate. Measures to increase the survivability of an air carrier accident will be costly, especially if retrofit of existing transport aircraft is involved, and they might involve additional restrictions on the passenger. Necessary technology and materials are available to solve some of the problems. The sticky problems will be public acceptance, cost and speed of implementation.

General aviation accounts for most aviation related fatalities and accidents, although air carrier safety problems receive the publicity. This will not change in the immediate future, but as the absolute numbers climb, they will attract sharper and more frequent attention. More stringent safety measures may be required to accelerate improvement in general aviation safety. Both regulatory and non-regulatory approaches should be possible. In any event, proposals for stronger general aviation safety measures are certain to be costly and controversial, especially stricter pilot certification and avionics requirements.

NOISE

The noise issue has been highlighted recently by the governmental decision to allow the Concorde to operate at Dulles and Kennedy for a trial period with a specified number of daily flights. The reactions, personal and political, have emphasized the importance of the noise problem to future expansion of the aviation industry, both technically and physically.

A prime requirement for system expansion is the construction of new airports or the expansion of existing facilities. In this area the problem of environmental impact (primarily noise) is almost equal to the question of where do we get the money. National attitudes have reached the point where plans for construction of a major airport are viewed by a portion of the population as a threat to the general welfare.

In this situation, aircraft noise is a prime FAA issue. Federal Aviation Regulation 36 is in effect and more stringent standards than set forth in this regulation are under consideration.

UNCERTAINTIES

Fuel and Materials Shortages

Capital Funds

Life Style

"Special Interest" Role In Public Decisions

Role of Government

39

Fuel and Materials Shortages

The interdependent economies of the United States, Canada, Japan and Western European countries remain vulnerable to OPEC oil embargoes. They are also vulnerable to embargoes of exports of raw materials which other cartels of resource exporting nations might impose. Moreover, by the turn of the century, proven reserves of many minerals will be nearly depleted. However, the developed nations generally recognize the long-run material scarcity problem and have begun policies and programs to make themselves more self-sufficient. They have the technical capability to find additional mineral deposits, substitutes for primary raw materials, and economically feasible means of recycling. They also have the organizational ability to enforce conservation measures. Ultimately, they also could ensure continued availability of such impacts through economic and political means.

All of the measures required to prevent future fuels and materials shortages are likely to be unpopular with one or more interest groups in the developed nations. Whether the developed countries acting together or separately can muster the will to accept these unpopular measures is uncertain at this time as is the recourse they might take if they find such measures insufferable.

Capital Funds

Capital expenditures fluctuate year by year in more volatile fashion than other indicators of socioeconomic conditions, such as GNP and population. Investment for new plant and equipment varies not only with future expected returns on the investment but also with capital stock depreciation and new technological innovations which make existing stock technically obsolete.

Air transportation industry capital expenditures in particular are determined by anticipated future economic conditions and profit pictures on one hand and capital fund availability or financial market conditions on the other. Expenditures on new plant and equipment averaged about 2 billion dollars per year for the air transportation industry for the past 3 years. The future capital fund requirements would also depend on the types of aircraft that aircraft manufacturers would be producing and on the optimum level of future fleet requirements.

In the recent past, airlines' operating costs have increased at a faster rate than revenues, often resulting in financial losses to many airlines. Future airline profit levels are highly uncertain.

There are also uncertainties about future financial market conditions and financial support by Federal, state and local governments, which also affect the overall aviation industry investment programs. The future course of aviation activities will certainly be influenced by how much and when facilities and equipment could be provided.

Market interest rate structure, levels of retained earnings, which could be used for internal financing, the amount of Federal subsidies, regulatory reform and profit levels of airlines and airport operators will all play important roles.

Lifestyle

Current lifestyle trends all seem to be conducive to more travel by air. For example, the women's liberation movement is encouraging women to have fewer children and to work. This provides more discretionary income for pleasure travel by air. Postponement of marriage and postponement of children after marriage ensure that more young adults have time and money available for air travel to recreational areas such as the Caribbean Islands and Western European ski resorts.

Other trends are favorable to increased air travel. For example, freer availability of charter fares will make air pleasure travel more economical. New areas, which Americans traditionally have not visited such as Micronesia and Africa will become tourist meccas. The increased life span should promote air travel. Older Americans will continue to migrate to retirement communities and to more moderate climes. There will be air travel associated both with change of residence and visits by relatives. The trends discussed above, however, are not immutable. Increased sophistication of telecommunications might provide an acceptable substitute for travel. The "new ruralism"— movement of a relatively small number of middle class young people to the country in recent years—may accelerate. This could result in strong value being placed on staying at home. Moreover, larger families could again become an American norm, especially if anti-abortion legislation passes and/or nursing home care of the elderly is no longer available at acceptable prices. Family enlargement could sharply reduce demand for air pleasure travel because of the concomitant reduction in discretionary income.

"Special Interest" Role in Public Decisions

In recent years the Congress has formalized the right of the public to have a voice in administrative decisions of the Executive Branch through the provisions of the Administrative Procedures Act, the National Environmental Policy Act and other laws. As a result, there is a trend for the organized segments of the public sometimes known as "special interest" groups to play a larger role in the formation of policy decisions by the government.

The FAA has a formal rulemaking process that permits all interested parties to be heard before new non-emergency regulations are issued. Yet, present relationships are not fixed; changes in our social and economic environment could cause the public's voice to be muffled or, vice versa, other circumstances could have the opposite effect. For instance, in Scenario (2) as the country struggles to gain control of a depressed economy, the relative influence of interest groups may be small compared to that of big government. Alternatively, if the conditions of Scenario (3) should come to pass, interest groups that are attuned to a concern for the environment may be accorded a more important role in the workings of government.

The FAA's statutory obligations have been broadened in recent years to include along with its initial responsibilities concern for such areas as environmental impact, carriage of elderly and handicapped passengers and security of air transportation from hijackings and bombings. Yet the balance of influence can shift, given the right conditions. High uncertainty lies in the exact factors involved, their influence, and the predictability of their occurrence.

Role of Government

The alternative futures postulated by this study describe a variable role for government which is a function of the socioeconomic circumstances of each scenario. For instance, in Scenario (5), which describes a utopia of plentiful resources and a booming economy, there is a diminution of government's role. Governmental economic influence is displaced by a revitalized, unregulated private sector. The FAA's responsibility for management of the National Air Traffic Control System is turned over to a quasi-public corporation.

At the other end of the spectrum is Scenario (4), which describes a future of Individual Affluence, but with a government that is large and pervasive. Every aspect of the country's economic life is tightly and effectively controlled by government.

Between these extremes we find Scenario (3) in which government plays a central but limited role in the allocation of resources. Governmental influence would undergo a moderate increase from present levels if this world were to be realized.

The role of government as set out in the scenarios or in the real world cannot be defined. The given societal and economic relationships do to some extent determine the role of government; but there are other forces which are nebulous and abstract in concept but which are none the less still powerful influences in this role definition.

Limitations imposed by the study methodology would not permit all of the possible forces to be brought into the scenario calculus when structuring the relationships within the several alternative worlds. The reader should keep in mind that identical socioeconomic factors and a different unprecedented event could result in a decidedly different role for government. Such major influences as a sudden shift in the political climate; a resurgence of religious influence in this country, with a dramatic change in lifestyles; an international crisis; or a natural disaster that decimated the population of one of our metropolitan areas—any one of these events could shape the future form and role of government. The role of government is a dependent variable influenced by uncertain circumstances. For this reason the extent of governmental influence in the scenarios should be taken as a given variable which is subject to change as any number of other factors vary.

THE "SCENARIO" AS AN ANALYTICAL TOOL

The dictionary definition of a scenario is "an outline or synopsis of a play; esp.: a plot outline used by actors . . ." Unlike most words borrowed from the jargon of a remote art, scenario retains its central meaning in the present use. The five condensed scenarios that follow are synopses or, better, plot outlines of alternative paths that our economy might follow toward the turn of the century. A scenario is a description of trends and events that describe a situation that might evolve. It is not a prediction of what will be. Rather, it is a picture of what might be. However, to say that a scenario describes something that might be is not to suggest that it is the product of whimsy. The scenarios that follow were developed to serve as tools for policy analysis. Toward that end they were developed through a systematic process to meet three criteria: they must be possible, plausible, and internally consistent. Without these qualities the scenarios would provide neither reason nor substance for analysis.

In general, the term "scenario" has been used in two different ways. First, it is used to describe a "snapshot in time" of conditions of important variables at some particular instant in the future. In the second concept, the term scenario describes a future history, that is, the narrative describes a process of evolution from present conditions to the time of interest. The former approach might be thought of as "cross-sectional" and the latter as "longitudinal." The latter approach was selected for the current study because the longitudinal approach can reflect causal relationships—how event "A" led to event "B." For policy analysis, the evolutionary paths themselves are often the central concern, for effective policy treats cause, not effect, and the implementation of effective policy can act to divert those paths toward desired ends.

The purpose of such a study is to reduce the uncertainty of the future. Yet the assertion that a scenario is not a prediction is an acknowledgement of uncertainty. In this study the problem of uncertainty is dealt with through the construction of a family of scenarios which illustrate the consequences of differing initial assumptions and cover the range of possible outcomes, i.e., covering all options. A family of scenarios is said to describe a "scenario space," that is, a range of alternative futures. The family presented here was determined by the desire to test the limits of the plausible scenario space by examining the conditions resulting from high growth and low growth along two dimensions critical to the demand for air transportation, Gross National Product and population. This provided a set of four combinations of initial assumptions: low population with high GNP *vs.* low population with low GNP and high population with high GNP *vs.* high population with low GNP. While these sets of assumptions did result in four discrete evolutionary paths that are quite distinguishable, one from the other, the initial assumptions established a bias toward the upper and lower limits of the scenario space, leaving the middle of the scenario space unoccupied. This was covered by a fifth scenario based on moderate GNP growth and low population growth.

To the practiced forecaster, everything discussed to this point can be accomplished by varying the inputs to an econometric model. The model would then generate alternative evolutionary paths complemented by a long array of detailed indicators. Although this can be done, it is not a satisfactory treatment of the future, for the relationships among variables, at any point in time along any evolutionary path, will be the same as they are today, since these are the relationships specified in the model. That contradicts the one thing we know about the future, that it will be different.

Since, historically, the forces of change are usually considered in terms of an event, which could be a discrete phenomenon or the culmination of a trend, the method used to develop these scenarios includes a technique for incorporating the impact of predicted future events on the variables that provide the basic structure of the scenarios. The application of this technique to all of the variables generated by an economic forecasting model would be an overwhelming task. But in a simplified scenario with only 18 socioeconomic variables, accommodation of the forces of change becomes quite manageable. Whether or not the events are explicitly

discussed in the narrative scenario, they become part of the analysts' understanding of the content and capability of the world from point to point along the depicted continuum.

Thus, scenarios are analytical tools, not predictions. They provide a means whereby the analyst can hedge against the uncertainty surrounding our one eventual future, by considering a variety of alternative future conditions and events, from the extreme to the commonplace and preparing a response to all the possible eventualities.

Turning to the scenario summaries, which follow, it is helpful to keep in mind that they were written as narrative histories and are understood best if viewed as if they were being recalled at some point in time beyond the year 2000.

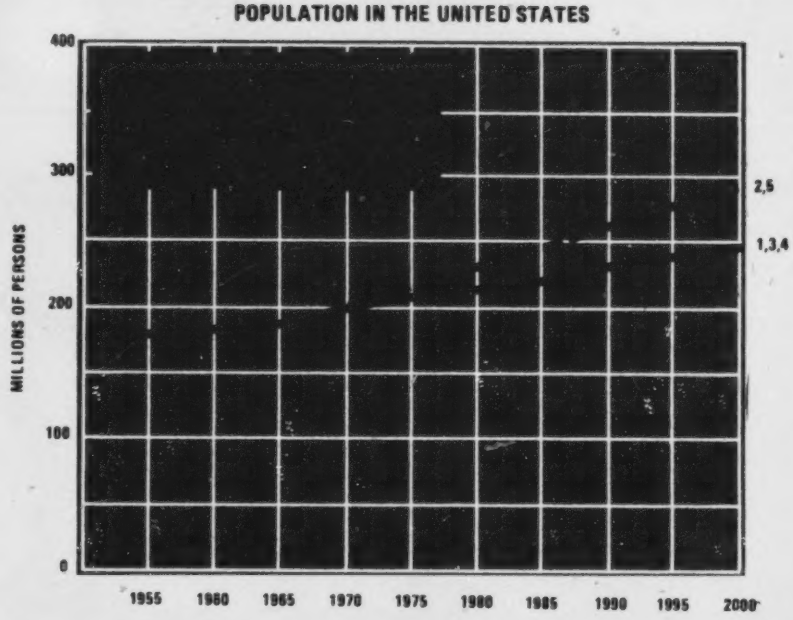
LIMITED GROWTH SCENARIO (1)

This possible evolution of our society is characterized by low growth in both Gross National Product and population. Following the energy crisis of the early 1970's, a series of related problems developed: a shortage of critical materials, increasing prices, limitations of capital, all leading to general economic instability. These gathering ills seemed to validate claims by adherents to The Limits to Growth philosophy, that growth is intrinsically wrong and that the economies of all developed countries ultimately have to stabilize. General acceptance of the deliberate limitation of growth as the only logical recourse led to the adoption of government and industrial policies and personal life styles that in terms of official control and personal constraint would have seemed impossible, even laughable in 1970.

Socioeconomic Conditions

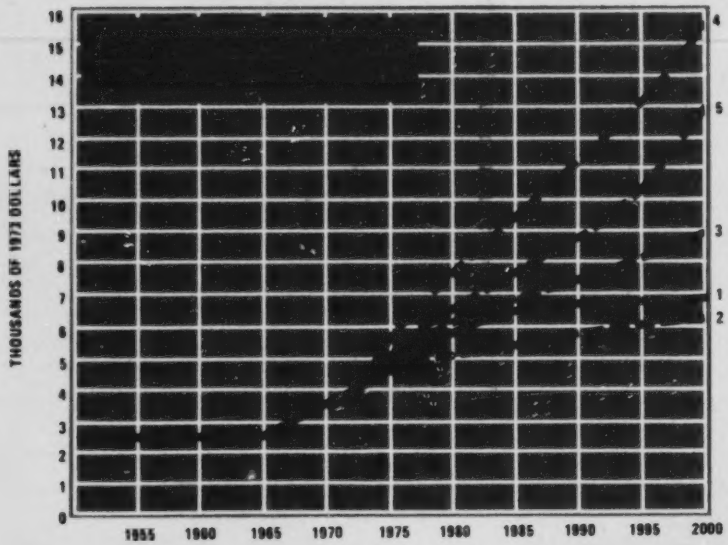
Demography. Economic uncertainties, coupled with government programs to limit population growth, maintained the low birth rate during the 1980's and 1990's at about the level experienced in the early 1970's. The population reached about 229 million by the year 1985, and 250 million by the year 2000, up from 208 million in 1972. By 2000, 80 percent of the population was over the age of 15, compared to about 74 percent in 1974. The urban environment became one of high population density. By the year 2000, due to encouragement by the government through its assistance to the cities, 90 percent of the population lived in metropolitan areas, compared with 71 percent in 1970. For the South and West, the percentage of people living in metropolitan areas increased almost to levels achieved by the Northeast and North Central regions of the country, approaching 85 to 90 percent by the year 2000.

Economic Conditions. In the late 1970's, conflicts among important interest groups about resource allocation produced rapid price increases, a decline in industrial productivity, and a general anxiety which resulted in significant deterioration of the entire economy. The high cost of energy,



coupled with the continued threat of oil embargoes, led to a national energy rationing program. Stockpiles of critical materials were built and the Office of Resource Distribution was established to implement rationing programs. During the 1980's the government accepted the notion that a stable economy was a desirable state of affairs and, in the 1990's, moved to attain that state. Annual GNP growth slowed to less than 2 percent per year from 1980 until the end of the century. In the 1990's, GNP growth was only 1 percent annually due to the decrease in population growth and to the constraints on resource usage brought about by high energy costs and changing lifestyles. Business productivity (as an index of output per man-hour) showed only a slight increase, rising by about 50 percent from the 1972 level. While the disparity in income between the highest and lowest sectors in the country diminished, competi-

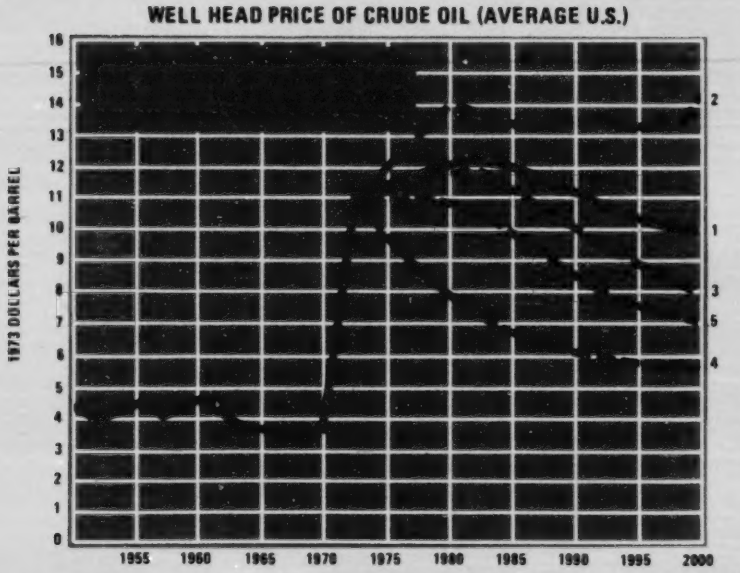
DISPOSABLE PERSONAL INCOME PER CAPITA



tion for jobs was relatively stiff and many young people, concerned about job and income security, were absorbed with work rather than fringe benefits. Society placed emphasis on financial security for the increasingly larger percentage of elderly. By 1985 the work week dropped to 38 hours and continued at that level to the end of the century. The purchasing power of the consumer was not strong enough to supply the individual with a standard of living substantially in excess of that of the 1970's. Personal income tax levels remained high. The rate of growth in personal consumption expenditures declined markedly from the post World War II period, reaching about $1080 billion by 1985 and about $1280 billion by 2000, up from $775 billion in 1972. The percent of personal consumption expenditures spent for food rose slowly from 27 in 1972 to 28 in 2000. And disposable personal income/capita which was $4233 in 1972 rose to $6580 in 1985 and increased to $7170 by 2000. Despite the hope that the decline in population growth would be economically beneficial, GNP/capita was only about $7750 by the end of the century as compared to$6300 in 1974. Emphasis was placed on income redistribution through taxation, with government enlargement of social services in the form of health services and education. The constant search for financial security encouraged people to work at more than one job, especially to provide a hedge against the threat of eventual layoffs.

Energy and Materials. Restoration of a balance between energy supply and demand in the mid- to late 1980's kept the price of fuel to a more moderate level than had been the case in the mid-1970's. By 1985 the cost/barrel of crude oil (in terms of average U.S. wellhead prices) dropped to $12. This trend continued and by the end of the century, the price was $10/barrel. Raw materials were also in short supply which caused increased prices. The price per pound of aluminum increased from just under 30 cents in the early 1970's to 65 cents in 2000, and the price per long-ton of iron ore increased from $12 in 1972 to $22 in 2000. Because of the uncertain energy supplies, which continued for the remainder of the century, telecommunications played an increasingly important role in all aspects of American life as they were viewed as being conservative of resources. Telecommunications were used extensively for exchange of business information, for business conferences, for visiting with friends, and as a continuous source of leisure time diversion in the home. By the year 2000, nearly 7 percent of the white-collar labor force was able to perform its work largely at home, using terminals to communicate with central offices. The telecommunication network provided substantial relief to transportation demands.

Human Resources and Lifestyle. Education continued to be of high value. It was heavily oriented toward job advancement and job security, supporting the role of the United States in a "post-industrial" world, and under the rationale of limited growth. By the 1990's the compromise between individual choice and the good of society was reflected in a changed urban lifestyle. Much child supervision and schooling was car-



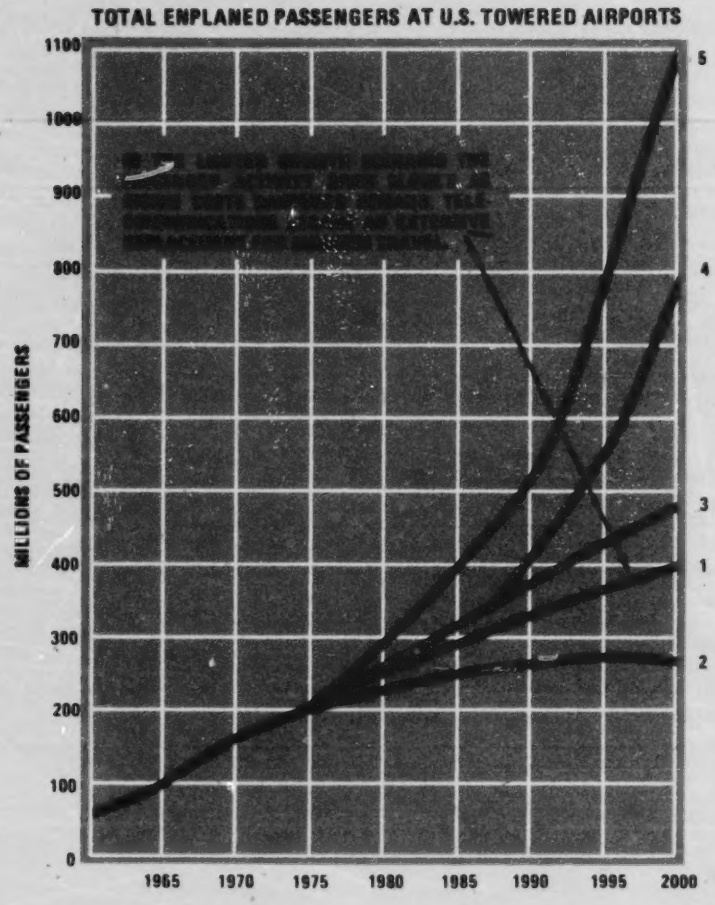
ried on by means of telecommunication. This depersonalization pattern for human development was paralleled by encouragement of individual cultural pursuits—which led to "consumption" of the sort that exerts less demand on materials and energy resources. As a result the value placed on travel, both business and pleasure was greatly diminished from that following World War II, but overall spending on leisure increased by 140 percent by 1985 and 164 percent by 2000 from the 1973 level. (In the period 1950–1973 it increased approximately 34 percent.) Hence, the 20th century closed with a United States characterized by low growth, both in an economic and demographic sense. Individual patterns of consumption were limited by societally accepted constraints in resource usage. However, many people believed their way of life was the prototype for developed countries in the 21st century.

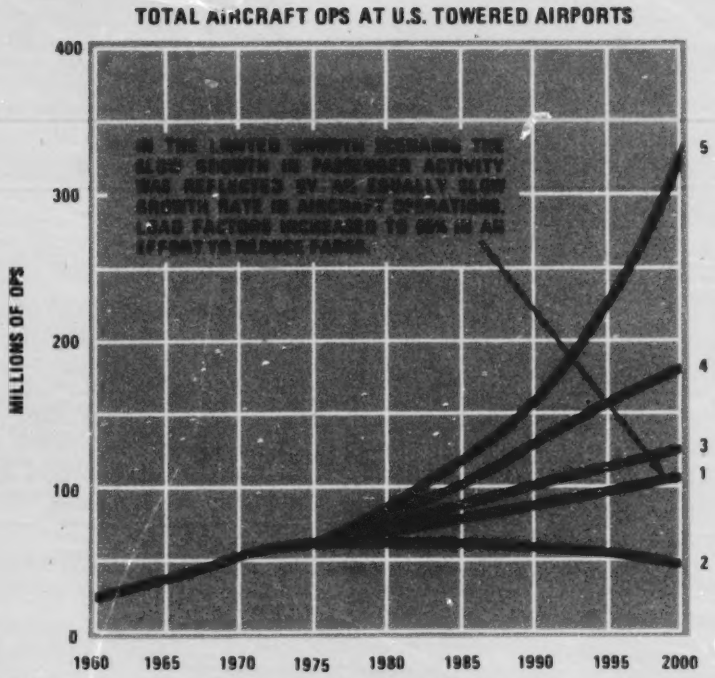
AIR TRANSPORTATION

Demand for Transportation and Competing Modes. The limitations placed on economic growth by public policy and the concentration of population in large urban areas slowed the growth of demand for all forms of transportation after 1975. Mass transit was encouraged by government subsidy and intercity rail was improved in the largest high-density corridors. Innovation in transportation centered on increasing the efficiency of existing patterns of transportation through improved inter-modal interface.

Aviation Activity. On the average, revenue passenger miles grew less than 3 percent annually. Air taxi type service grew at a somewhat higher rate providing feeder service to major airports, and replacing larger carriers on low-density routes. Average stage lengths declined as flights were consolidated to increase aircraft utilization. Average trip lengths increased slightly because of new short-haul rail facilities. Average load factors rose from 54 percent to 65 percent during this period as airlines adjusted routes and aircraft to reduce costs. As a result of these adjustments, and because of slow replacement of the fleet and of slow introduction of new stretched aircraft, the average aircraft size only rose from 120 passengers to 137 passengers over the 25-year period. Average airline fares increased by 50 percent, in real terms, between 1975 and 2000. Airlines tried to cut costs by reducing fuel and labor costs, but increased costs were a major factor in reducing the growth of demand. Air cargo increased at a slow growth rate averaging 3 percent, as cargo shipping costs increased by 50 percent between 1975 and 2000. General aviation experienced a 3 percent growth rate, as both business and pleasure flying became less attractive for economic reasons.

Aircraft Technology. Innovations in aviation technology emphasized improved operating economies, particularly in fuel use. Significantly different aircraft types were not added to the fleet, but stretched versions of the existing, narrow-bodied two- and three-engine aircraft were intro-





duced. Because of slow demand growth, the air carrier mix changed slowly and only gradually incorporated these improved aircraft. The air carrier fleet mix continued to be dominated by two- and three-engine narrow-bodied vehicles.

Airports. Aircraft operations increased at an annual rate of about 2.5 percent for the mid-1970's to the end of the century. Higher growth rates existed in the earlier years. Improvements to existing airports were adequate to meet most of the increased demands.

Air Traffic Control. The Federal Government reduced its investment in research and development in air traffic control technology after 1985, as aviation expansion slowed. System-wide installation of the upgraded third generation air traffic control system was begun in 1985, and it was the basic system in operation for the rest of the century. Aircraft accident rates and the actual number of accidents declined both for air carriers and for general aviation. Air carrier fatalities, however, did not decline significantly because of larger planes and higher load factors.

The Role of Government. The Federal Government devoted decreasing attention to aviation and other transportation issues because of budgetary constraints and higher priorities given to other economic issues. The Federal Aviation Administration reduced its research and development role and its airport funding activities. The Civil Aeronautics Board, on the other hand, increased its control over routes and fares in order to preserve the economic viability of the air carrier system. Federal policies to reduce energy use through high taxes and tariffs on petroleum had an important impact on the aviation system throughout the period.

AIR CARRIER FLEET MIX

	1970	1975	1980	1985	1990	1995	2000
4-ENGINE WIDE BODIED (747-TYPE)	1%	5%	6%	6%	5%	5%	5%
4-ENGINE NARROW BODIED (707-TYPE)	27%	22%	20%	16%	10%	5%	0%
2-3 ENGINE WIDE BODIED (DC-10 TYPE)	0%	6%	5%	10%	12%	15%	18%
2-3 ENGINE NARROW BODIED (727-TYPE)	58%	55%	53%	55%	59%	60%	62%
SMALL SHORT HAUL (50 PASSENGERS)	14%	12%	13%	13%	14%	15%	15%
S S T	0%	0%	0%	0%	0%	0%	0%
4-ENGINE EXTRA LARGE (1000 PASSENGERS)	0%	0%	0%	0%	0%	0%	0%
JET STOL (150 PASSENGERS)	0%	0%	0%	0%	0%	0%	0%

The air carrier fleet grew from a total of 2,420 aircraft in 1970, to 3,140 in 1985, and 3,790 in 2000.

58

59

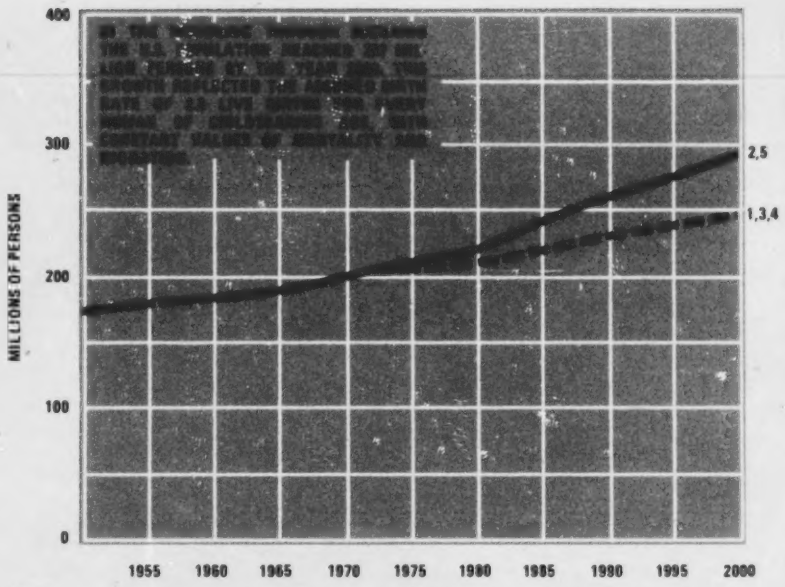
MUDDLING THROUGH SCENARIO (2)

Despite low growth in Gross National Product, population grew at a high rate and things went downhill from the 1970's. The United States never seemed to be able to "get it all together." When it tried to repair inflation, recession followed; when recession was the target, inflation accelerated. Muddling Through was the norm. Cohesive policies which lasted beyond one presidential term were very unusual. The result, inevitably, was frustration. Who was at fault? Industry said government; government said industry; the public faulted both; and government and industry claimed the public did not understand. Large corporations were nationalized. Regional authorities were established. For several reasons, the last quarter century was not a repeat of the depression years of the 1930's. In the latter part of the century, the nation was more urbanized, Federal programs had reduced unemployment rates, large-scale quasi-public corporations functioned with adequate but reduced efficiency. But the feeling of depression was inescapable. This was the modern depression—and it was long lasting.

Socioeconomic Conditions

Demography: Despite economic hardships and the crowded conditions which became characteristic of the cities of the latter part of the century, there was no downturn in population growth. The population reached 245 million in 1985 and 297 million by the year 2000, compared with 208 million in 1972. This came from an increase in birth rate from the level of the 1960's and early 1970's. The birth rate rose to 2.8 live births per woman of childbearing age in the early 1980's. By the year 2000 the median age was only slightly in excess of 30 years, with 27 percent of the population under the age of 15. The flow of people back into the cities exceeded the rate of urban renewal and development. By the end of the century, 90 percent of the population resided in urbanized areas and signs of crowding were evident in almost every aspect of urban life. These difficult economic conditions resulted in a decline from expected migration to the South and West, and by 2000 these areas showed hardly any gain in their share of the U.S. population

POPULATION IN THE UNITED STATES



from the mid-1970's. By the year 2000, the percentage of the population living in the metropolitan areas reached nearly the same level for most of the country, though the South remained below 90 percent and continued to lag the rest of the country by a few percentage points.

Economic Conditions: The struggle to maintain a balance between resource supplies, resource demands, and imported resources continued to have serious economic impacts on domestic economic behavior. Both the average wellhead price of crude oil in the United States and the price of raw materials increased over the years. Crude oil prices increased until 1980, when the government decided to once again press for increased use of coal. The price of crude oil then decreased slightly, but in 1985 began to rise again as the threat of a reestablishment of the oil embargo by OPEC forced the United States to accept arbitrarily

60

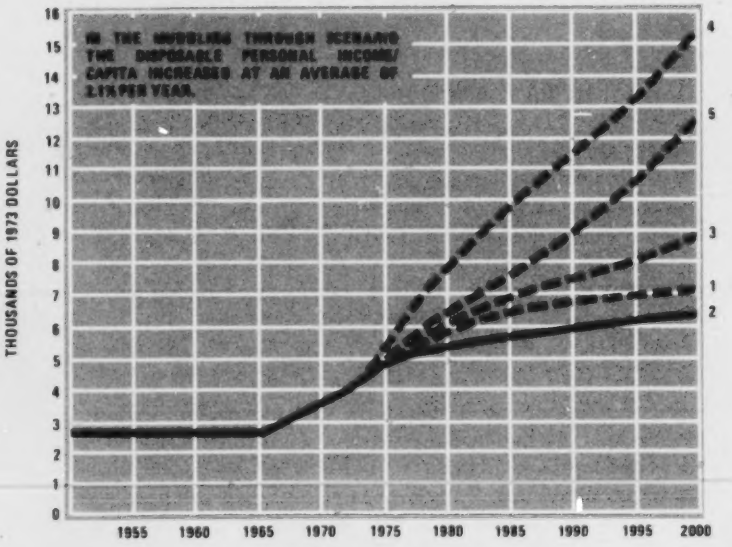
61

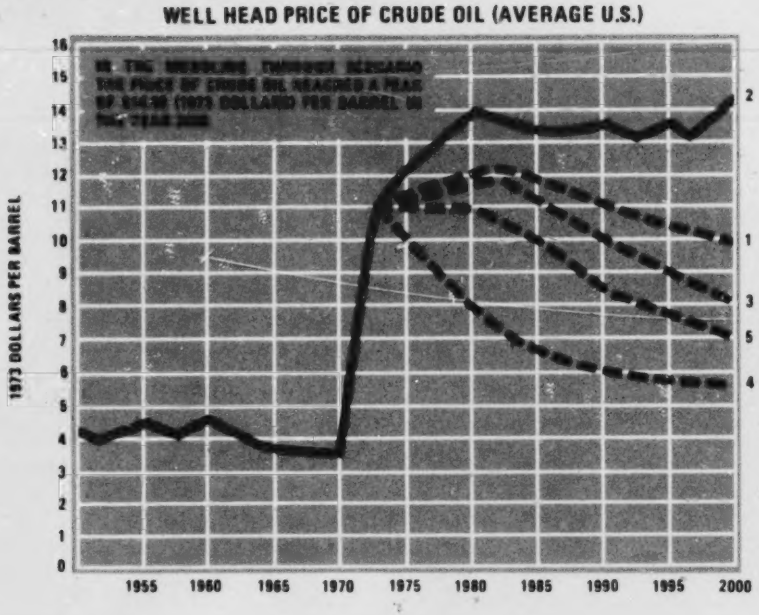
increased prices. The price per pound of aluminum increased from 28 cents in 1972 to 75 cents in 2000, and the price per long-ton of iron increased from $12 in 1972 to $25 in 2000. Government measures to control wages and prices were accompanied by only small increases in relative productivity (as an index to output per man-hour). GNP was growing slowly as the end of the century approached even with the large population increases. In 1972, GNP totaled $1.2 trillion and in 2000, $2.1 trillion. The high cost of energy resulted in high costs for fertilizer and agricultural operations. Agricultural output became marginal and, by the middle of the 1980's, many smaller farms were abandoned. The demand for jobs continued to thwart advances in automation. In an effort to minimize travel, telecommunications began to be used extensively for exchanges of business information and conferences. Real disposable income, like GNP, showed little growth, with the per capita level in 2000 having reached $6400, compared to $4233 in 1972. Similarly, GNP/capita exhibited low growth rates. And personal consumption expenditures reflected the small increase in disposable personal income. The high costs of fertilizer had a serious impact on the price of food. In 1972 the percent of PCE spent on food was 22 and in 2000 had increased to 31 percent.

Energy and Materials: With the increasing threat of the reestablishment of an oil embargo by the OPEC nations, a system of energy and resource rationing was introduced. Energy rationing was instituted principally to support the needs of agriculture and transportation. Environmental constraints were relaxed to encourage broader use of coal and attempts were made to allocate energy supplies. Conditions continued to worsen toward the end of the century, leading to the nationalization of the petroleum industry in 1990.

Human Resources and Lifestyle: The percentage of government spending for human services increased rapidly as the century progressed. In 1972, the government allocated 53 percent of its budget for human services, whereas in 2000 the percentage increased to 69 percent. The population density in the urban environment increased disproportionately to the services needed by the population, in terms of housing, transportation, education and so on. Though many people held down more than one job or worked longer hours, productivity grew slowly. With the government's policies de-emphasizing luxuries and nonproductive activities, the amount of money the populace spent on leisure activities increased slowly on a per capita basis. In fact, the growth rate between 1975 and 2000 averaged only 2.5 percent per year, compared to an average annual growth rate of 6.4 percent for the preceding 25 years. Recreational activities tended to be nonenergy dependent and low cost. The strain on resources was evident in the lack of reliability of fundamental services. There were blackouts and brownouts due to shortages or breakdowns in electrical generating equipment. There often were delays due to equipment failure in the transportation system.

DISPOSABLE PERSONAL INCOME PER CAPITA





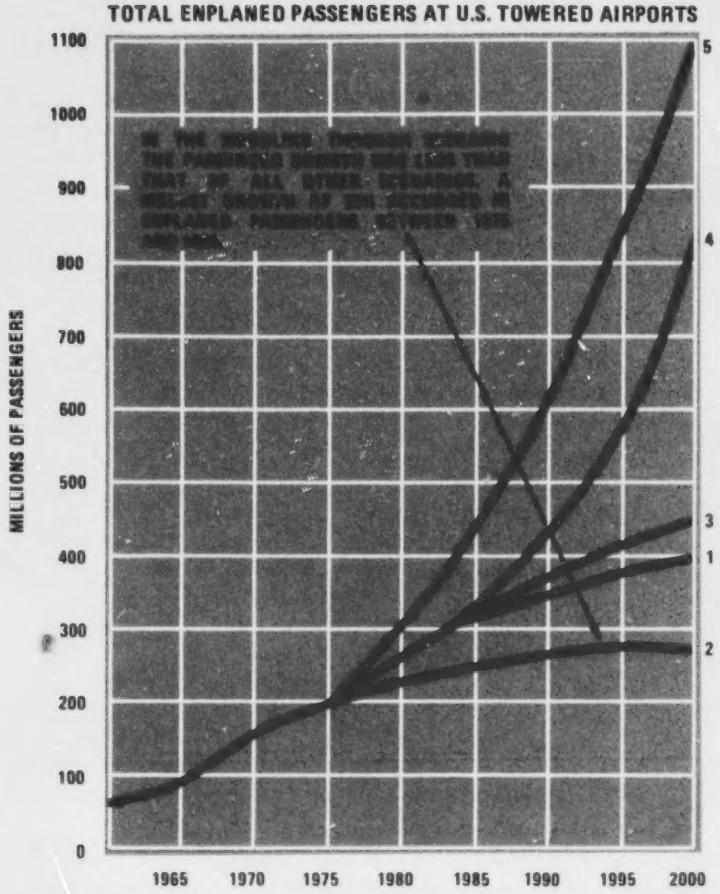
Air Transportation

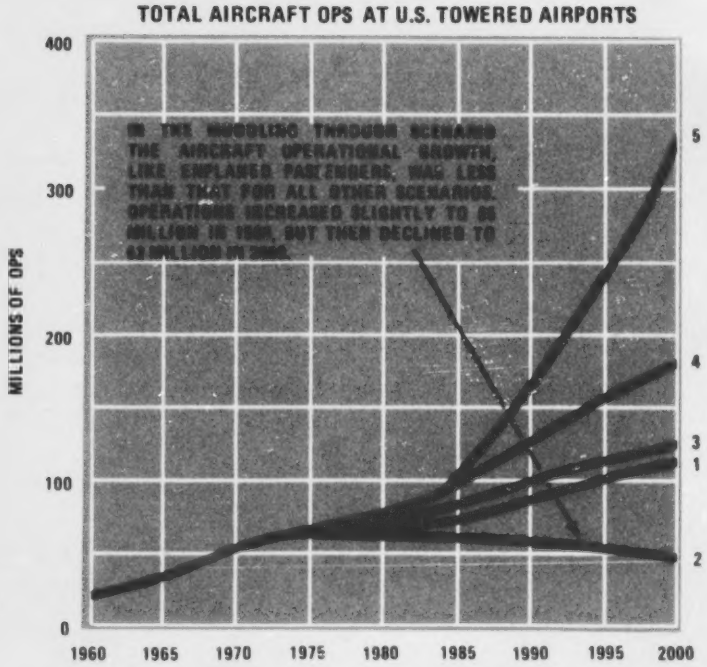
Demand for Transportation and Competing Modes: Economic hardships and stationary personal income levels combined with high costs to stagnate demand for transportation. Because of deteriorating economic conditions, the Federal Government was forced to take an increasing role in the management of the transportation system. The transportation system which existed in 2000 had basically the same structure as that of the mid-1970's. Nationalization of all public interstate transportation took place in the mid-1990's in an attempt to restore financial stability. Multi-state regional authorities were used to manage transportation systems to direct inter-modal coordination.

Aviation Activity. While overall aviation activity declined, some areas experienced modest growth. Revenue passenger miles increased from about 132 million in 1974 to a peak of 170 million in 2000 before leveling off. Enplaned passengers also grew from 1975 through 2000 by about 25 percent. This passenger growth was accommodated with a declining number of operations through the use of slightly larger aircraft on the average, and significant increase in load factors. Fares increased steadily but slowly, increasing 50 percent in real terms from 1975 to 2000. Fare increases were held down by direct and indirect government subsidy as well as by reduced service quality.

Aircraft Technology. As u result of low levels of research and development and minimal demand for new aircraft, changes from 1975 aircraft types were minimal. The major technological innovations were in fuel reduction achieved by the introduction of more efficient jet engines after 1990. Changes in fleet mix were accomplished more by changes in retirement rates than by the addition of new vehicles, because the fleet size declined steadily. Operating costs rose sharply from 1975 through 1985 because of increased fuel costs and taxes and increased maintenance on older aircraft. After 1985 costs increased only at an average rate of one percent reflecting the change in operating policies brought on by nationalization.

Airports. Total aircraft operations at United States towered airports increased slightly from 57 million in 1974 to 65 million in 1980, but then declined to 52 million in 2000. Air carrier operations declined by 10 percent overall while general aviation activity declined by 20 percent. As a result of declining activity, the 1975 airport system was more than adequate to meet demand through the year 2000. Congestion delays declined at most airports. In fact, many general aviation airports were closed and converted to nonairport use. Nationalization of the airport system forestalled the closing of many smaller municipally-owned airports and prevented major losses of these aviation system resources. Airport finances reached a crisis in the mid-1980's when falling operating revenues from airport users failed to cover fixed expenses built into air-





ports by optimistic expansions in earlier decades. States and municipalities turned to the Federal Government for support. The National Air Transportation Corporation, already responsible for air carrier operation, took over bankrupt airports and purchased marginal ones. A few large self-sustaining major hub airports remained in local hands. The National Air Transportation Corporation was required to eliminate or reduce service at airports which could not be made economically viable. As a result, some airports in smaller communities were closed permanently.

Air Traffic Control: Improvements in air traffic control systems were implemented slowly, because of the anticipated low rates of growth in operations. There was a selected implementation of the UG3rd that basically stopped after 1985. Congestion delays declined because of decreased traffic volume. Accident rates and the total number of accidents declined over the period for the same reason.

The Role of Government: Through the use of regulated quasi-independent government corporations modeled after the example of Amtrak in

the 1970's, the Federal Government acquired the major operating responsibility for airports and air transportation throughout the United States. A new independent regulatory agency set service standards for all modes. To finance the aviation system, increased taxes on users were imposed and taxes were also increased on fuel use to discourage consumption.

AIR CARRIER FLEET MIX

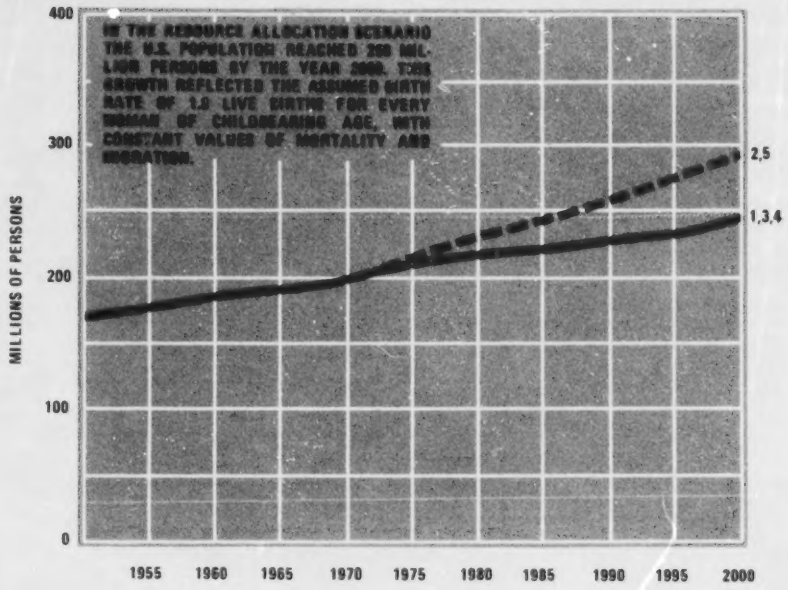
	1970	1975	1980	1985	1990	1995	2000
4-ENGINE WIDE BODIED (747-TYPE)	1%	5%	6%	6%	5%	5%	4%
4-ENGINE NARROW BODIED (707-TYPE)	27%	22%	20%	17%	12%	8%	4%
2-3 ENGINE WIDE BODIED (DC-10 TYPE)	0%	6%	8%	9%	10%	11%	12%
2-3 ENGINE NARROW BODIED (727-TYPE)	58%	55%	51%	52%	56%	59%	64%
SMALL SHORT HAUL (50 PASSENGERS)	14%	12%	15%	16%	17%	17%	16%
S S T	0%	0%	0%	0%	0%	0%	0%
4-ENGINE EXTRA LARGE (1000 PASSENGERS)	0%	0%	0%	0%	0%	0%	0%
JET STOL (150 PASSENGERS)	0%	0%	0%	0%	0%	0%	0%

The air carrier fleet grew from a total of 2,420 aircraft in 1970 to 2,670 in 1985 and reduces to 2,430 in 2000.

RESOURCE ALLOCATION SCENARIO (3)

This scenario gives coverage to the middle of the scenario space with moderate growth of Gross National Product and low population growth, but claims no higher probability then the other four scenarios. Resources, particularly energy resources, were in short supply. Groups of nations, functioning essentially as cartels, unilaterally established resource prices and continually threatened to withhold supply unless consuming nations met requirements established by the suppliers. Throughout the world, tension built and ebbed. The exporting nations remained reluctant to repatriate capital in ways which were useful and productive to the importing nations. Once a year, one or the other of the cartels would withhold supplies for a period of several weeks, and the importing countries coped as best they could. As supply fluctuated, so did prices. Inevitably, the response was a determined move toward self-sufficiency—to reduce the demand for critical imports. Political and intellectual energy was focused on how to grow, given these resource constraints. The answers were: to develop indigenous resources, to allocate stringently, to recycle, and to plan.

POPULATION IN THE UNITED STATES

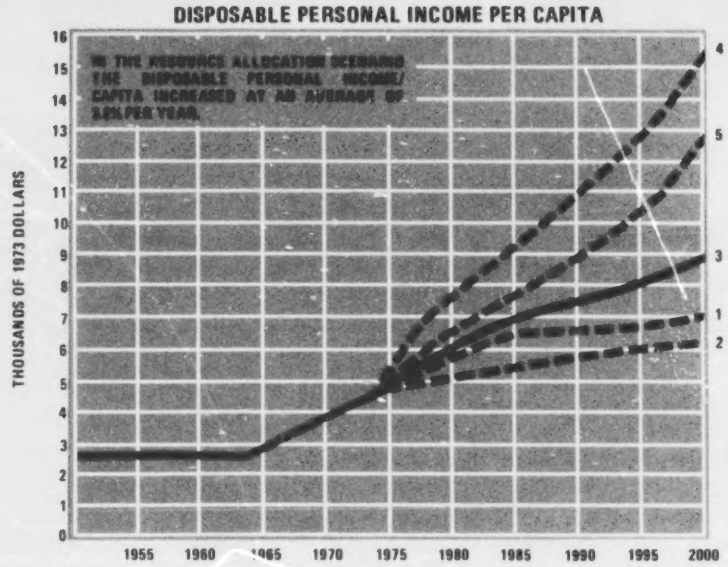


Socioeconomic Conditions

Demography: Population growth in the United States continued at 1970 levels for the remainder of the century, reaching about 229 million in 1985 and about 250 million by the year 2000. The emphasis that was placed on the planned allocation of natural resources was carried over to the improvement of human resources as well. The median age, which was 28 in 1970, reached 30 by 1985 and 32 by the year 2000. By the end of the century, 80 percent of the population was over the age of 15. Urban growth was strong as a result of a realization that economic integration of the city and the suburb was necessary. At the end of the century, 90 percent of the U.S. population lived in urban areas, compared to 71 percent in 1970. By the 1990's mass transit systems were meeting the needs of high density cities. In the South and the West, the share of the national urban population overtook that of the rest of the country, and the two regions comprised nearly 55 percent of the total national metropolitan population by the year 2000. These two regions had included only 45 percent of the United States metropolitan population in 1970. Net gains in population due to migration accelerated the urbanization of the South and, by the close of the century, all four major regions of the country had about 90 percent of their population residing in metropolitan areas. Several megalopoli evolved: one running from Boston, Massachusetts to Richmond, Virginia; a second in California, from San Francisco to San Diego; and a third from Milwaukee, Wisconsin through Chicago, Detroit, and Cleveland and terminating in Buffalo, New York. By the year 2000, over 50 percent of all intercity communication messages and passengers traveled between points within the confines of the megalopoli as compared with approximately 30 percent in 1965. Within each megalopolis structure there remained urban concentrations around the several nuclear cities. In other parts of the

country, urban concentration produced large cities of high density which tended to be well separated from each other.

Economic Conditions: During the latter part of the 1970's the economy was relatively unstable and inflation rates were high. By the end of the decade legislation, deriving largely from the work of the Resource Allocation Board, provided for a government commitment to research and development of alternative energy sources. At the same time, plans for mass transportation stressed fuel conservation and effective land use. By the middle of the 1980's the efforts on research and development and on construction helped stabilize the economy and a large measure of national confidence returned. Business productivity (as an index of output per man-hour) spurted in the 1980's equaling the most productive period since World War II. The index in the early 1980's rose by a factor of 1.3 from the 1971 level, and by the end of century the index had more than doubled from 1971. Annual GNP which had declined for a period in the 1970's grew at a rate of 3 percent by the end of the century. Disposable income growth grew moderately and the purchasing power of the consumer was slowly strengthened and maintained from the mid-1980's to the end of the century. Personal Consumption Expenditures (PCE) spent for food rose minimally from 22 percent in 1972 to about 25 percent in 2000. As transportation development was keyed to the increased density of urban life, many industries, prodded by government tax incentives, returned to urban areas in search of an adequate supply of labor. And, as the cities became economically viable, property taxes and local income taxes were able to support urban budgets. Gasoline taxes were used to support development of all phases of those forms of ground based mass transportation which were shown to be environmentally attractive and which made efficient use of energy and raw materials. And as ground based mass transportation attracted more users, it had less need for Federal support at the same time that automobile usage, which provided much of that support, was declining. The price of crude oil in the U.S. began to decline slowly in the early 1980's due to programs of energy conservation and increasing energy supplies from alternative sources. While at the same time producers attempted to keep oil competitive with other forms of energy by reducing its price. Intercity automobile travel fell to levels which existed during the 1960's (706.1 billion passenger miles) and by the end of the century was under half a trillion passenger miles per year.



Energy and Materials: By the 1990's scientists achieved the breakeven experiment in nuclear fusion so that a controlled thermonuclear reaction producing a net output of energy was possible. Though the ultimate payoff from thermonuclear energy was seen to be great, the century ended with commercial applications still to be realized and energy conservation programs were still in force.

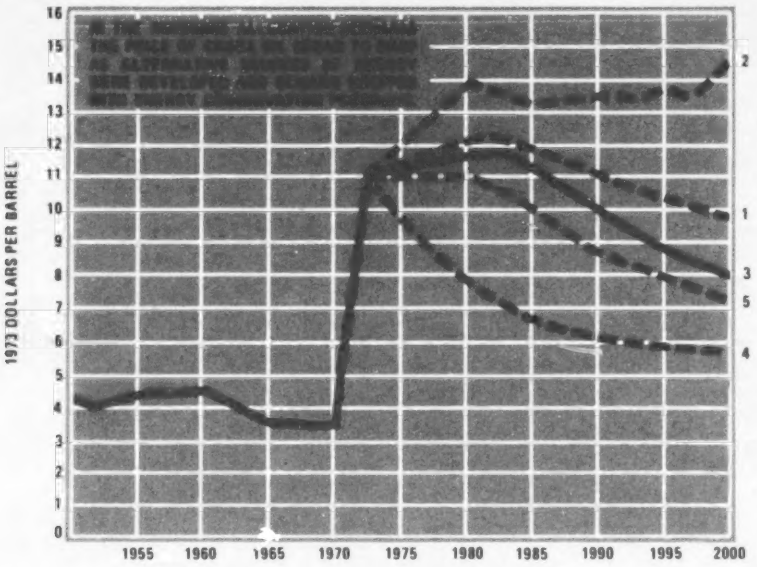
Human Resources and Lifestyle: Government spending for social welfare increased substantially, from 53 percent of the Federal budget in

71

72

1972 to 68 percent by the end of the century. The length of the work week declined from about 39 hours in the early 1970's to 38 hours during the 1980's and was down to about 35 hours by the late 1990's. Although fuel costs tended to remain relatively high, per capita disposable personal income was adequate to meet the costs of public transportation, whose costs were controlled by adjusting subsidy levels for various modes (in particular, mass transit systems). But patterns of mobility tended to be more local than they were in the 1970's, as the revitalized urban center had a high degree of economic and cultural self-sufficiency. With both parents at work and children in school most of the day, much leisure time was devoted to bring all age levels of the family together periodically. The amount of money that was spent per capita for leisure activities increased steadily over the years, from $281 in 1975 to $364 in 1985, and to $559 in 2000. Thus, the United States at the end of the 20th century was able to balance energy and material demands with supplies, largely fostered by the government's encouragement of careful energy usage and the development of successful patterns of urban life.

WELL HEAD PRICE OF CRUDE OIL (AVERAGE U.S.)

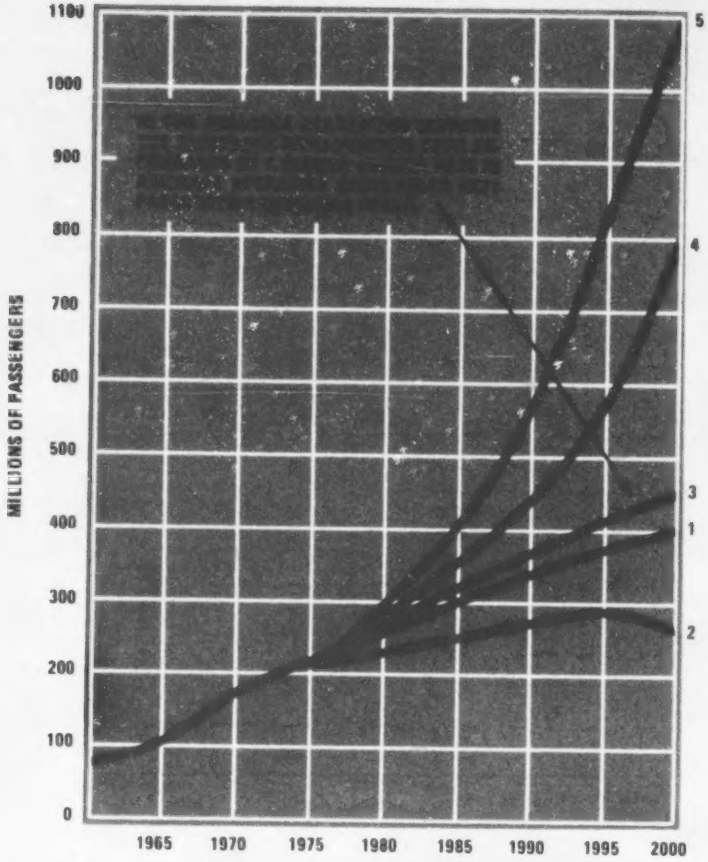


Air Transportation

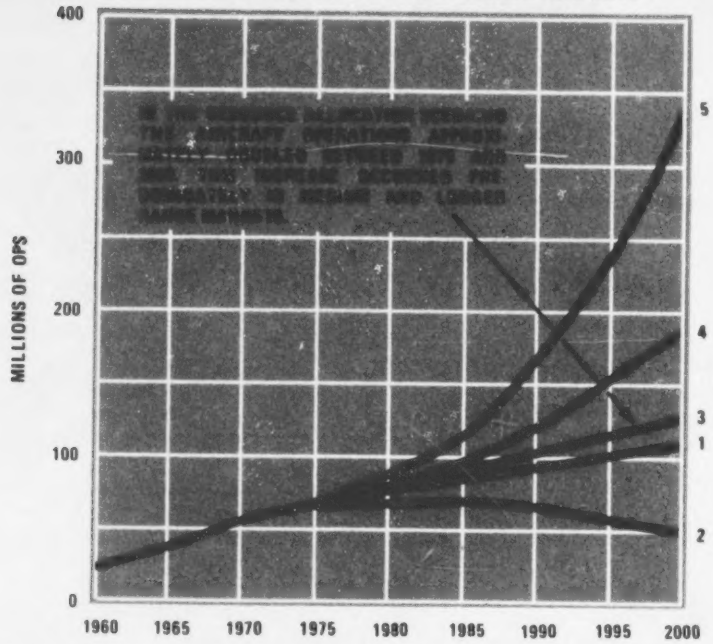
Demand for Transportation and Competing Modes: Rising prices and shortages of essential resources, particularly fuel, created problems in all areas of transportation in the later 1970's. Inadequacies in the transportation system had threatening feedback effects on all parts of the economy. Though rising fuel costs for private cars did little to relieve urban vehicular congestion, it did at last make clear the need for public mass transit. The need for Federally-sponsored, integrated, multi-modal transportation systems became politically acceptable as a hoped for way out of the frustrations which were affecting nearly everyone. As a result of government action to allocate resources, the 1980's saw far reaching changes in transportation: (1) automobiles became smaller, more efficient, and were relied upon for relatively short distance travel; (2) intra-corridor high-speed ground transportation was developed for the Northeast, the coast of California, and in the Midwest; and (3) efficient mass transit systems were being evolved which helped revitalize urban centers. Together, these changes provided for a more efficient use of energy and other raw materials, and improved land use.

Aviation Activity: Demands for all types of air transportation grew at a moderate rate from 1975 to 2000. Rates of growth were higher in the first decade and declined in percentage terms toward the end of the century, reflecting moderate economic growth and the availability of competitive transportation modes. Compounding these modest rates over the last twenty-five years of the century however, resulted in a significant increase in the size of the air transportation system. Air transport passenger enplanements increased by over one and one-half times, cargo revenue ton-miles grew by 125 percent and general aviation operations more than doubled. Domestic revenue passenger miles increased from 132 billion in 1975 to over 300 billion in 2000. Short-haul transporta-

TOTAL ENPLANED PASSENGERS AT U.S. TOWERED AIRPORTS



TOTAL AIRCRAFT OPS AT U.S. TOWERED AIRPORTS



tion however, faced significant competition from ground modes, and this was reflected in the increased average stage length of domestic flights. Air cargo tonnage grew at an average annual rate of 3 percent. Most of the cargo revenue ton-miles continued to be carried in bellies of passenger transports but all-cargo service grew by over two and one-half times in the twenty-five year period. General aviation operations increased from 43 million in 1974 to 105 million in 2000. Increased business travel was largely responsible, as rising costs discouraged growth of pleasure flying.

Aircraft Technology: Technological developments in aviation emphasized improvements in operating economics, fuel efficieny, and noise reduction. In addition, new vehicle types were introduced. In the mid-1980's, two-engine wide-bodied jets became prominent; a new reduced energy transport in a narrow-bodied configuration was introduced in 1990; 150-passenger quiet jet STOL aircraft began service in the same year; a long-range extra-large passenger and cargo carrying transport started commercial service in 1995. Supersonic transports were not introduced into domestic U.S. service before 2000 because of environmental and

75

76

energy conservation concerns. Improvements in aircraft technology helped slow the growth of operating costs. However, increased costs for labor and capital and higher taxes resulted in an increase in real operating costs.

Airports: Total aircraft operations at towered United States airports increased from 57 million in 1974 to 125 million in 2000. Air carrier operations grew from 13 million to 17 million and general aviation increased from 43 million to 105 million. To accommodate this increase in activity, a number of new regional airports were constructed or converted from military use in the most crowded hubs. Most of these new airports were introduced into service in the 1990's, when sufficient demand improved financing capacity, and the availability of high-speed ground links to urban centers combined to make large new airports economically attractive. In the period before 1990, capacity increases

AIR CARRIER FLEET MIX

	1970	1975	1980	1985	1990	1995	2000
4-ENGINE WIDE BODIED (747-TYPE)	1%	5%	7%	8%	9%	9%	8%
4-ENGINE NARROW BODIED (707-TYPE)	27%	22%	19%	15%	9%	3%	0%
2-3 ENGINE WIDE BODIED (DC-10 TYPE)	0%	6%	8%	10%	13%	16%	20%
2-3 ENGINE NARROW BODIED (727-TYPE)	58%	55%	51%	54%	56%	58%	59%
SMALL SHORT HAUL (50 PASSENGERS)	14%	12%	15%	13%	12%	11%	10%
S S T	0%	0%	0%	0%	0%	0%	0%
4-ENGINE EXTRA LARGE (1000 PASSENGERS)	0%	0%	0%	0%	0%	1%	3%
JET STOL (150 PASSENGERS)	0%	0%	0%	0%	1%	2%	4%

The air carrier fleet grew from a total of 2,420 aircraft in 1970 to 3,210 in 1985 and 3,540 in 2000.

77

78

were accomplished largely by internal improvements at existing air carrier airports and the development of new special-purpose general aviation airports which provided sufficient capacity improvements to satisfy the growth of aviation activity in this period.

Air Traffic Control: Improvements in air traffic control technology resulted in reduced congestion and improved safety. The upgraded third generation air traffic control system, most of which was in place by 1995, increased overall efficiency. Increased automation in air traffic control systems continued through the 1990's. Wake turbulence detection and reduction perfected in 1990 allowed reduced aircraft separations. Throughout the period the Federal Government followed a philosophy of increased automation in order to end the rising costs of the air traffic control system. Despite large expenditures in research and development and major investments in implementation, increased costs continued to be a problem for the air traffic control system. The benefits of improved air traffic control included reduced delays in high traffic density control areas and improved safety. Air carrier accidents and fatality rates declined as a result of improved control procedures. Air carrier fatalities, however, rose because of increased aircraft size and load factors. General aviation accident rates declined sharply and the number of general aviation accidents dropped by 25 percent.

The Role of Government: The Federal Government increased its responsibility for the coordination and financing of all transportation modes during the last two decades of the century. The Federal Aviation Administration coordinated its activities more closely with the other modal administrations of the Department of Transportation and increased its funding of research and airport construction. Its activities were supported by increases in aviation user charges, including ticket taxes and fuel excises.

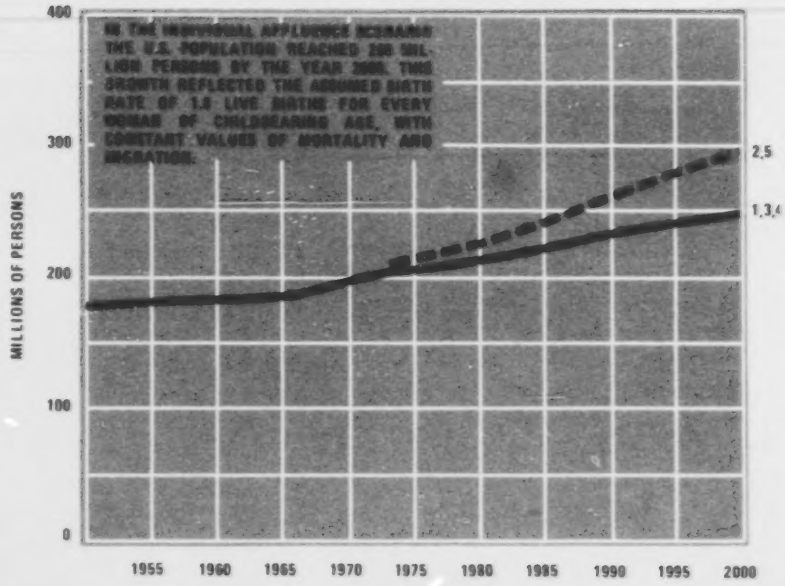
INDIVIDUAL AFFLUENCE SCENARIO (4)

Low population growth during high economic growth gave each citizen a larger share. This was a planned United States. Its government was centralized—its goals, explicit. Population growth was low and in line with newly developed energy and material supplies. The government policies were anticipatory, not reactive. There was in this world a great deal of environmental consciousness and regulation; policies were constantly tested to determine whether or not they met the broadest public need.

Socioeconomic Conditions

Demography: Efforts to restrict birth rate hel[illegible] the population to about 229 million by 1985 and to less than 250 million by the end of the century. The birth rate was 1.8 live births per woman of childbearing years, and by the year 2000, approximately 80 percent of the population was over the age of 15, compared to about 74 percent in 1974. The threat of decay which the core cities faced in the 1970's was removed through a successful policy of apportioning both Federal and state aid to cities. This aid was justified in part on their daytime population increases, serving as a measure of importance of the city to the surrounding community. This policy encouraged suburbs to yield to annexation pressures from the cities. For the administration and development of specific functions (e.g., transportation), metro governments were often formed which had the power to levy taxes on both income and property in their areas. The stabilization of population growth did not alter the rate of urbanization of the population. The South and West continued to have the largest urban growth rates and, by the close of the century, these two regions contained half of the U.S. population and also accounted for 50 percent of the total national metropolitan population, compared to 45 percent in 1970. By 2000, nearly 90 percent of the population resided in metropolitan areas, as compared with 71 percent in 1970, and suburbs which immediately surrounded central city tended to develop in tight rings. Four large corridors and several smaller ones formed. These were Boston to Richmond, Buffalo to Milwaukee, San Francisco to San Diego,

POPULATION IN THE UNITED STATES

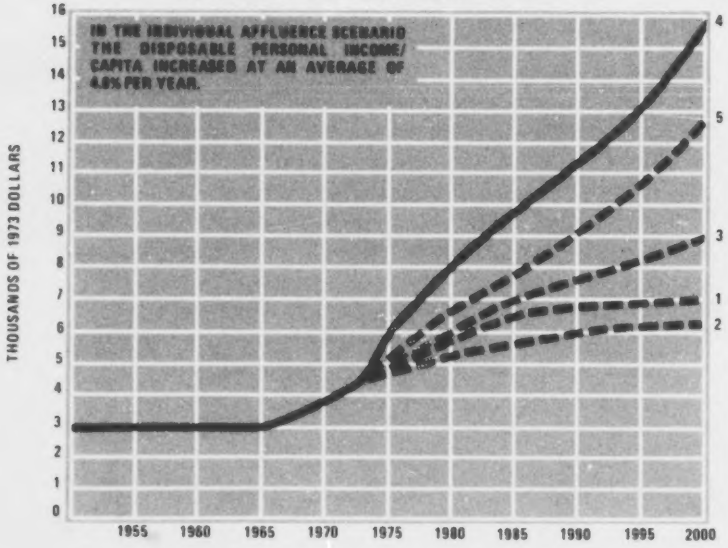


Dallas-Houston-San Antonio, Seattle to Portland, New York to Albany, Philadelphia-Harrisburg-Pittsburgh, Miami to Jacksonville and Orlando to St. Petersburg.

Economic Conditions: The frustration during the mid-1970's over the inability to solve simultaneous inflation and recession was attributed, in part, to the lack of adequate planning and to ineffective policy formation and execution on the part of the government. The government sought to remedy this situation and planning was key to its activity. GNP grew rapidly with the advent of new technological developments that solved energy supply problems. In 1972, GNP totaled $1.2 trillion and by the close of the century had increased to $4.1 trillion. Business productivity (as an index of output per man-hour) grew to an unprecedented high by the year 2000 and allowed marked increase in personal affluence.

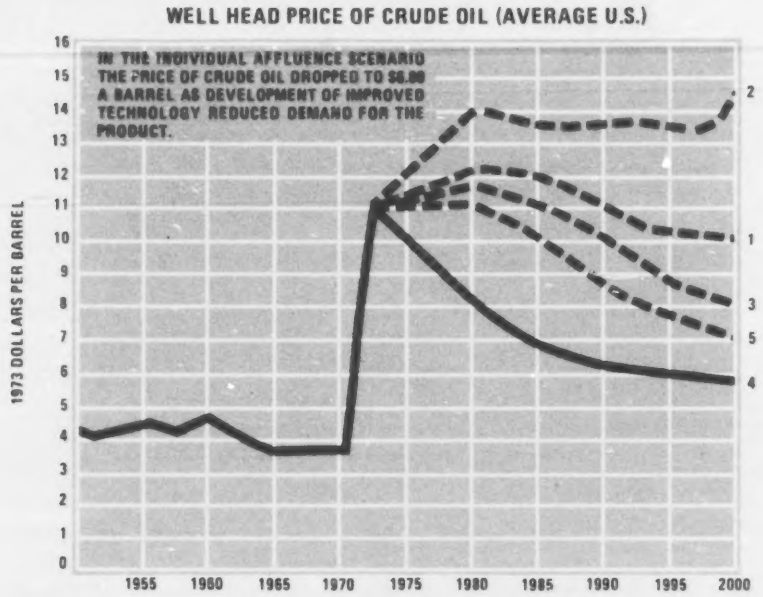
In the areas of transportation, communication, and housing, the Federal Government played an active role by guaranteeing construction loans to secure necessary capital formation. Disposable personal income per capita and GNP per capita also showed phenomenal growth. Disposable personal income per capita rose from $4233 in 1972 to $15,700 in 2000, and GNP per capita climbed from $5800 in 1972 to $16,500 in 2000. Personal consumption expenditures also reflected the tremendous growth in societal wealth. In 1972 personal consumption expenditures for the entire nation totaled $775 billion and by the end of the century had increased to $2800 billion. Also, the length of the work week was reduced, so that by the year 2000 it was approximately 36 hours per week compared to 39 hours in 1972. Vacations for many workers lengthened to nearly 2 months per year. Perhaps the most novel change in American life was the view that the low density suburban populations which clustered about nuclear cities were responsible for the economic viability of the city. The equalization of the tax structure, so that the suburbs gave proportional support to the cities which could then provide adequate transportation and other social services, reversed the trend toward demographic decentralization. The health of the cities encouraged the return of industry, and the cities once again became the centers of economic and cultural development. Urban cores were accessible by mass transit, and travel into the city for work and pleasure gave emphasis to the continuing need for vital urban life.

DISPOSABLE PERSONAL INCOME PER CAPITA



Energy and Materials: Technology had begun to exploit new energy resources and advanced engineering techniques were developed for substituting a wide range of industrial materials which were in short supply. As a result, the price of crude oil started to decline in the late 1970's. The price per pound of aluminum and the price per long-ton of iron ore increased slowly until the end of the century. The decline in population growth, which occurred in the early 1970's, aided in bringing about a balance between supplies and demands. Government policies were directed toward spurring indigenous energy sources which could support a highly automated capital intensive industry and acceptable conservation measures.

Human Resources and Lifestyle: Education became prized as a cultural asset and was not necessarily connected with career advancement. The level of median education climbed from 12.2 years of schooling in 1972 to 15.1 years in 2000. This high level of education was also made possible by industrial funding of general education for its employees, by major portions of the work force taking educational sabbaticals, and by the increased amount of leisure time due to reduction of the work week. By the start of the 21st century, technological advances and the control of population growth allowed for productivity levels which resulted in an ever expanding range of individual material benefits. Spending on leisure activities rose from $249 per capita in 1973 to $510 in 1985 and to $840 in 2000, and more money could be spent on luxuries and cultural pursuits. These heavy expenditures were accompanied by moderate in-



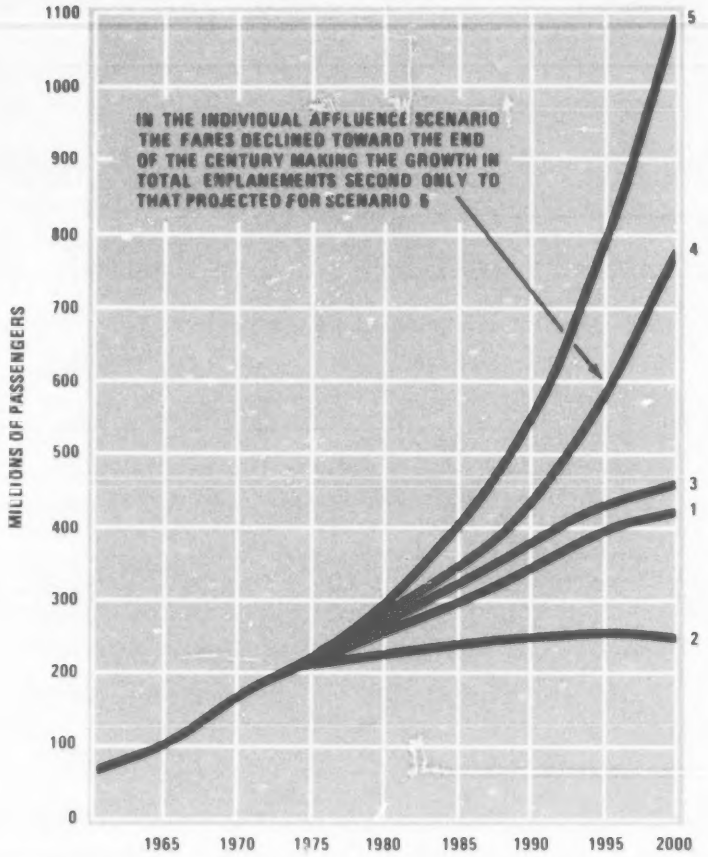
creases in necessities, such as food, in an absolute sense. But, the percent of personal consumption expenditures for food dropped from 22 percent in 1972 to about 20 percent in 2000.

Air Transportation

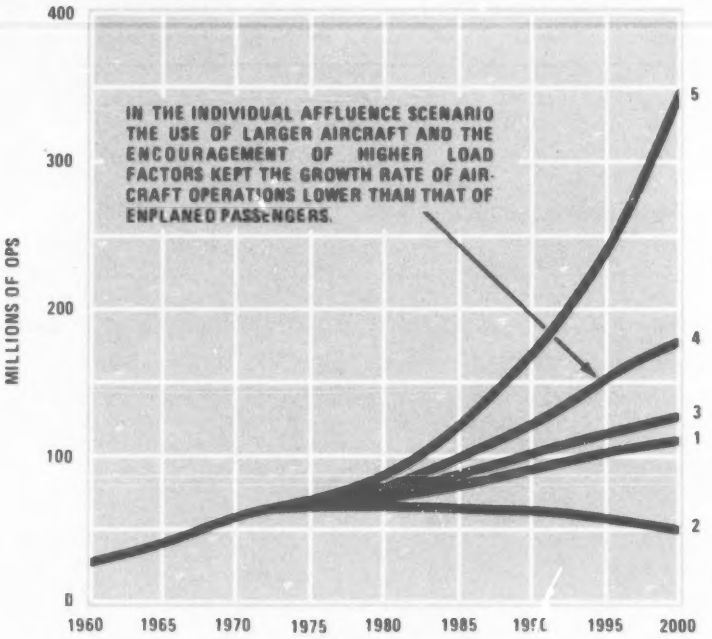
Demand for Transportation and Competing Modes: The rapid increases in business activity and personal income greatly stimulated demand for transportation. Demand growth was tempered somewhat, however, by trends in lifestyle created by environmental consciousness. Demand for aviation was affected also by the encouragement of high-speed ground transportation as an environmentally acceptable mode for intercity travel. The automobile continued to be used for transportation needs throughout the suburban areas, and by the year 2000, electrically powered vehicles were being used by people living in high-density urban areas. In urbanized areas, extensive mass transit was developed. In the several large urban corridors high-speed ground transportation was developed to compete with aviation in short-haul markets.

Aviation Activity: Domestic revenue passenger miles grew at an average rate of over 5 percent annually from the late 1970's until the turn of the century. Operations did not keep pace with this growth rate because of increasing aircraft size, longer average trip length, and rising load factors. Trip lengths increased because of ground competition with short-haul air transportation. And load factors were kept high by government regulation to improve economics and reduce environmental impacts. Passenger fares rose slowly through 1990 and then declined through the end of the century, yielding an average annual cost increase of less than 1 percent over the entire period. Fares were kept down by improved technology and by regulatory action to improve operating efficiency. Consistent with the increasing scope of government planning and control, federal regulatory policy began to control routes and schedules more strictly after 1985. By eliminating competing flights between city pairs at close time intervals and by the use of larger aircraft and the encouragement of higher load factors, costs to passengers were reduced while airline profits, distributed on a pool basis, remained high. Air cargo tonnage increased at an annual rate of 9 percent, resulting in an sevenfold increase in cargo shipped over 25 years. All-cargo flights increased dramatically in this period, because of high economic growth and strict control of the number of passenger flights. Nevertheless, two-thirds of the cargo was shipped on passenger flights. General aviation operations grew at an annual rate of 5 percent, with somewhat lower growth rates in the 1990's. General aviation demand was spurred by increased business activity, a large growth in a affluent individuals with leisure time, and the availability of convenient airports. Growth was retarded, however, by increased costs of operation resulting from higher user charges and increased equipment requirements and in the case of pleasure flying, by the lack of airport capacity and by increased competition from alternative leisure activities.

TOTAL ENPLANED PASSENGERS AT U.S. TOWERED AIRPORTS



TOTAL AIRCRAFT OPS AT U.S. TOWERED AIRPORTS



Aircraft Technology: A variety of new aircraft models were introduced into the air carrier fleet between 1975 and 2000. In addition, incremental improvements in existing aircraft types provided increased capacity, and operating efficiency, and reduced environmental impacts. New aircraft introduced included extra-large transports for passenger service on long-haul, high-density markets and for air cargo, beginning in 1990. In the same year, 150 passenger jet STOL aircraft began to compete with conventional aircraft and high-speed rail for short-haul passengers. Improvements in aircraft technology helped reverse the rise in operating costs for aircraft by 1985. In the last decade of the century, direct operating costs declined. The average size of aircraft in the air carrier fleet increased from 120 seats per aircraft in 1970 to 160 in 2000.

Airports: Total aircraft operations in the United States tripled between 1975 and 2000. Air carrier operations doubled to 25 million annually, and general aviation operations increased by 225 percent to over 150 million annually. After exhausting all non-capital options it became apparent that to accommodate the increasing traffic, a major restructuring of the national airport system was necessary after 1985. Several

large regional airports were built to serve major hubs, and existing facilities were largely converted to feeder service and general aviation. Additional feeder airports were constructed to accommodate growing demand in metropolitan areas for air taxi service to long-haul airports, for short-haul trips, and for general aviation activity. New airports were designed to include all possible noise-impacted areas within their boundaries. Advance land banking made it possible to assemble these large sites.

Air Traffic Control: Major improvements in air traffic control were required to meet rapidly rising demand. Upgraded third generation air traffic control was introduced in 1980. A fully-automated fourth generation system was installed beginning in 1990. Control of wake turbulence allowed reduced separation standards which contributed, along with new airports, to the elimination of major congestion delay problems after 1985. The cost of development and implementation of improved air traffic control technologies were high for the Federal Government and for system users. All aircraft operators were required to make increasingly large investments in avionics in order to enter most parts of the airspace, but due to the strong economic situation there was minimum effect on growth of aviation.

The Role of Government: The Federal Government exercised a high level of control in the planning, development, and operation of the aviation system. Although transportation planning was done on a multi-modal, regional basis, and financed by a single transportation trust fund which supported all modes, aviation continued to receive ample funds to finance its growth. The administration of the air traffic control system required increased funding, but staffing increases were minimized by high levels of automation.

AIR CARRIER FLEET MIX

	1970	1975	1980	1985	1990	1995	2000
4-ENGINE WIDE BODIED (747-TYPE)	1%	5%	8%	10%	12%	10%	9%
4-ENGINE NARROW BODIED (707-TYPE)	27%	22%	15%	8%	2%	0%	0%
2-3 ENGINE WIDE BODIED (DC-10 TYPE)	0%	6%	9%	13%	15%	16%	17%
2-3 ENGINE NARROW BODIED (727-TYPE)	58%	55%	53%	53%	54%	56%	55%
SMALL SHORT HAUL (50 PASSENGERS)	14%	12%	15%	16%	14%	13%	11%
S S T	0%	0%	0%	0%	0%	0%	0%
4-ENGINE EXTRA LARGE (1000 PASSENGERS)	0%	0%	0%	0%	1%	2%	3%
JET STOL (150 PASSENGERS)	0%	0%	0%	0%	2%	3%	5%

The air carrier fleet grew from a total of 2,420 aircraft in 1970 to 3,410 in 1985 and 5,660 in 2000.

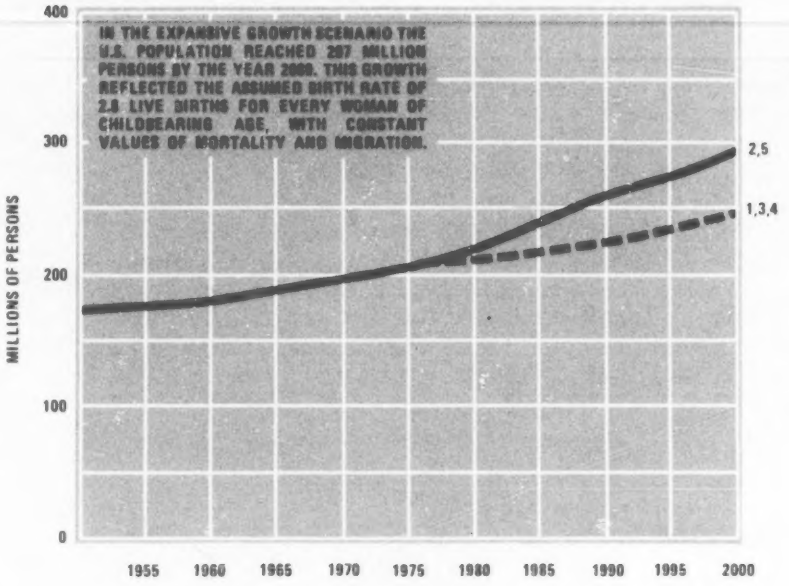
EXPANSIVE GROWTH SCENARIO (5)

This scenario incorporates high growth in both Gross National Product and population. The United States confronted the problems which inhibited its development—attacked them vigorously—and solved them with the old "American Spirit." The nation found it possible to create images of what might be and then to put into place policies to achieve its end. Technology still worked, and the means of achieving the technological solutions were through free enterprise. As the private sector grew in vitality, the public sector—government—reduced its relative size and propensity to intervene and control. The emphasis was on individualism; on corporate achievement.

Socioeconomic Conditions

Demography: The technological advances that resolved the resource availability problem stimulated economic growth and created a forward looking national pride. Both the optimism of the economic outlook and the national mood of vitality had a somewhat accelerating effect on family formation and birth rate. In 1985, the population reached nearly 245 million and by the year 2000 it just exceeded 297 million, as compared with 208 million in 1972. Birth rate returned to a level of about 2.8 births per woman of childbearing age. About 74 percent of the population was over the age of 15 by the year 2000, about the same ratio as in 1974. The median age was just under 30 years. The tendency to decentralize prevented the population in the urban centers from completely dominating the suburbs, which continued to grow. But by 2000, about 85 percent of the population resided in metropolitan areas, compared to about 71 percent in 1970. By 2000, the South and West, which now comprised over 50 percent of the U.S. population, still contained less than one-half the total national metropolitan population, compared with 45 percent in 1970. Various urban/suburban continuous corridors could be identified quite clearly by the 1980's. The large corridors included the North East corridor from Boston to Richmond, the Great Lakes corridor from Buffalo to Milwaukee, the West corridor from San Francisco to San Diego, and the Texas corridor including Dallas,

POPULATION IN THE UNITED STATES



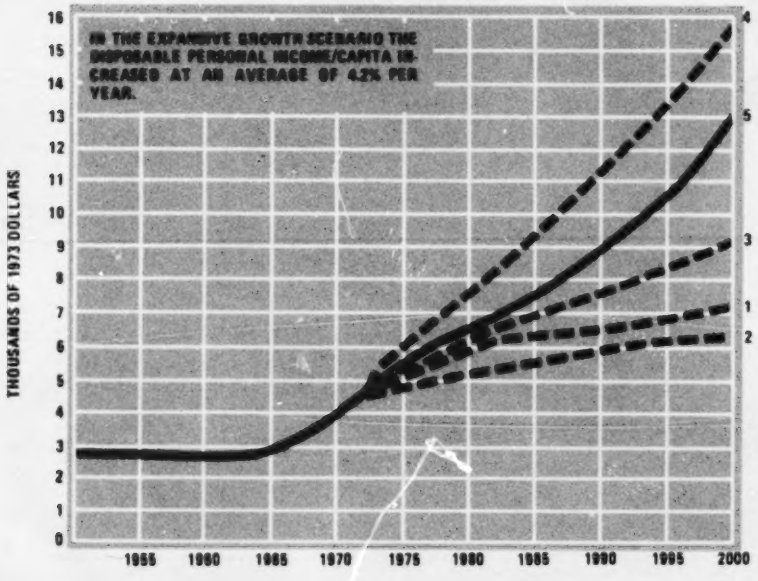
Houston, and San Antonio. Some of the smaller corridors included Seattle-Portland, New York-Albany, Philadelphia-Harrisburg-Pittsburgh, and a Florida corridor which ran from Jacksonville to Miami.

Economic Conditions: The ability to resolve conflicts between resource supplies and demand through technological advances, stimulated economic growth. And the problems of availability of crude oil and raw materials were largely overcome. While the Federal Government subsidized research and development, providing the stimulus for the growing technologies, it gave relatively free rein to industrial expansion. As a result of these events, GNP grew rapidly and, by the 1990's, was increasing at a rate greater than 5 percent per year. In 1972, GNP totalled

91

92

$1.2 trillion and by the year 2000 rose to $4.3 trillion. Real disposable income accelerated at rates parallel to GNP growth, and per capita disposable personal income increased rapidly from $4233 in 1972 to about $7630 in 1985 and about $12,900 in the year 2000. Accompanying this trend, GNP/capita jumped from $5800 in 1972 to $14,000 in 2000, a growth of 4 percent per year at the close of the century. Industrial decentralization tended to keep the population relatively dispersed. And as patterns of decentralization were encouraged, more industrial production was located close to supply centers for needed materials. The vigor of the economy and the emphasis on mobility, which allowed individuals to move frequently in order to maximize their opportunities, resulted in relatively low levels of unemployment. The achievement of high technical productivity allowed industry to accept a 38-hour work week by 1985, along with month-long vacations and a host of ancillary employee benefits ranging from health care to subsidies for



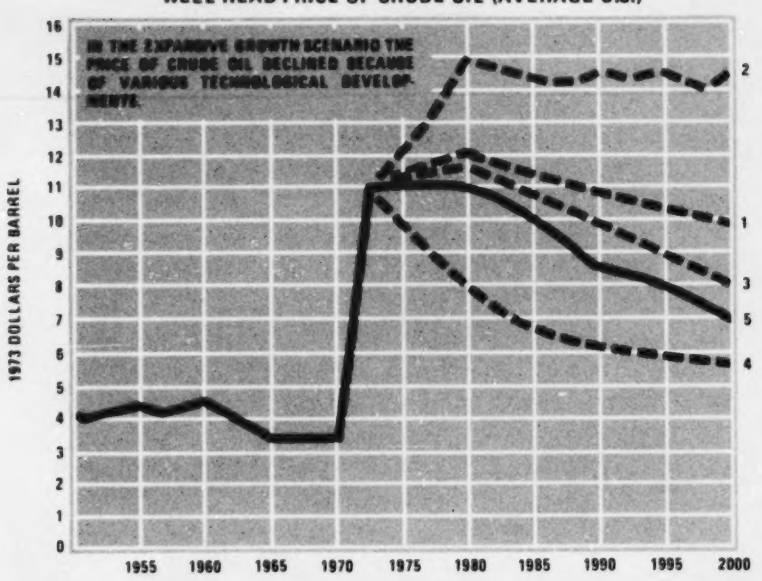
advanced education. Personal consumption expenditures, which were $775 billion in the early 1970's, rose to about $1330 billion in 1985 and to about $2720 billion by 2000, and shifts in spending occurred. For example, while the percentage of personal consumption expenditures on food declined from 22 in 1972 to about 21 in 2000, this represented a substantial increase because of the absolute growth of personal consumption expenditures.

Energy and Materials: Prices of raw materials did not escalate drastically, largely due to the availability of energy at reasonable costs. The price per pound of aluminum and the price per long-ton of iron ore increased slightly over the years. High levels of domestic mobility resulted in high demand in the transportation sector. The price of crude oil decreased from the late 1970's to 2000 due to various technological developments. In the late 1970's the average wellhead price of a barrel of crude oil was around $11, and this increased slightly; then started to fall as alternative domestic energy sources increasingly were able to influence energy prices. The close of the 20th century saw the price of oil at $7 barrel.

Human Resources and Lifestyle: Education was considered to be of high value. Many employees took educational sabbaticals under company and government sponsorship and the median level of education of the population rose steadily. By the end of the century the United States showed little anxiety about population growth. Through the advance of technology, society was able to satisfy its needs and to develop in an almost uninhibited fashion. Population density was held down by patterns of decentralization and people were able to maintain a high degree of community identity. With increasing abundance of domestic energy supplies, the end of the century found a population free to move throughout local, national and international areas. Recreational pursuits were not inhibited by energy limitations. The funds spent on leisure activities increased substantially over the years with per capita expenditures increasing from about $250 in 1973 to about $470 in 1985 and about $680 in 2000. The relatively high dispersal of population followed the

93

94

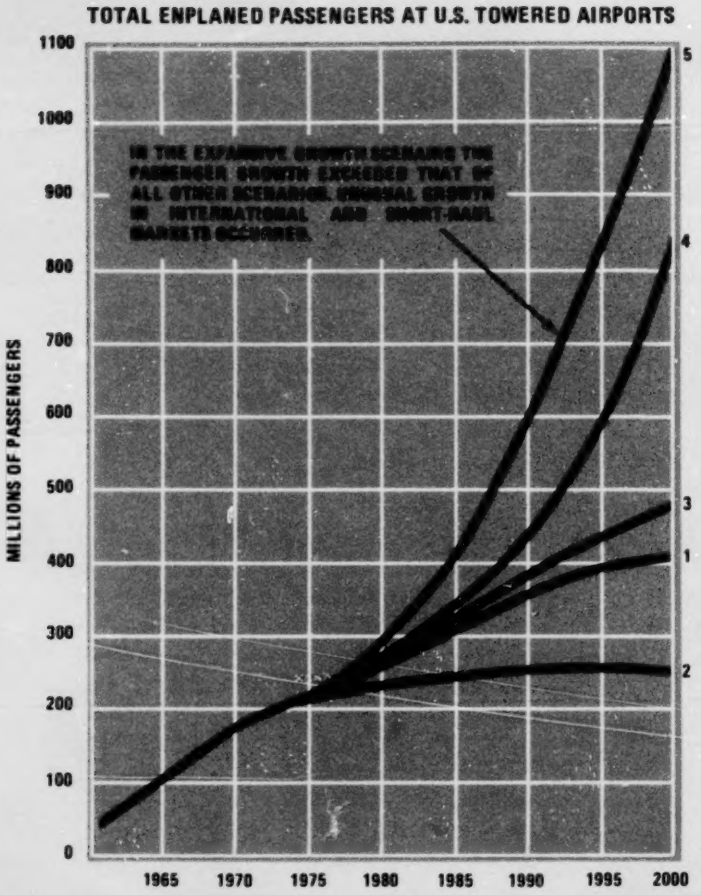


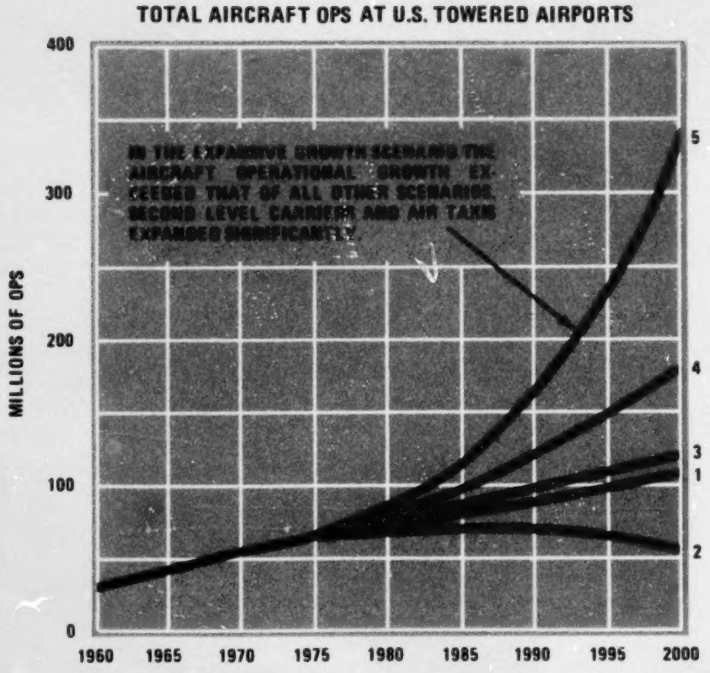
trend toward industrial decentralization along corridors. New towns and cities were established as the population spread out across the country, and new urban-suburban corridors formed almost naturally. While urban centers provided some focus for economic and cultural activities, by the end of the century, point-to-point travel patterns in the low density suburbs were dominant. By the 1990's, new communities could locate without any serious energy induced limitations, due in part, to the ability to economically tap geothermal and solar energy sources.

Air Transportation

Demands for Transportation and Competing Modes: Increased demand for all modes of transportation resulted from expansive growth of business activity, leisure time and income. A high emphasis was placed on mobility at the local, national and international level. Private vehicles, in the form of the automobile and personal aircraft, were popular because of the independence they offered. The highway system was extensively expanded. Mass transportation for intra-urban transit did not grow sufficiently to offset a continued growth in private vehicles, because decentralization of industry and commerce continued to make the automobile necessary. In the urbanized corridors located in the densely populated Northeast, Midwest, and Far West regions, high speed ground transportation was functioning competitively by the mid-1980's. The aviation system remained the primary means for long distance travel, while short distance travel tended to be split between the aviation system and high speed ground transportation. The vigorous growth of these many transportation modes created complex problems of intermodal transfers. Coordination of different modes was hindered by competitive factors.

Aviation Activity: The air transportation system faced increasing demand for passenger service in long- and short-haul markets, general aviation, and air cargo throughout the period 1975 to 2000. Passenger traffic increased strongly, with domestic revenue passenger-miles increasing over 250 percent from 1975 to 2000, an average annual growth rate of over 6 percent. Short-haul air travel, which grew at an average annual rate of 8 percent, was spurred by the development of the STOL airport system in the 1990's and by the relatively slow improvement of high speed rail inter-city ground transportation, hindered by a slowing of public investment. A laissez faire attitude toward the regulation of air carriers led to a proliferation of types and levels of service for travelers. In general, service types split into two main categories: high-cost, regularly scheduled, high-frequency, low load factor service attracting time-conscious business travelers, and low-cost, irregularly scheduled charter-type service for pleasure travelers. Air cargo increased at an average rate of 12 percent during 1975 to 2000, spurred by rapidly growing domestic and foreign trade, particularly in high technology products and perishable foods. Most of this cargo growth was accommodated in the bellies of passenger-carrying aircraft, but all-cargo activity experienced a suf-





ficiently rapid growth to spur the development of all-cargo airports in the 1990's. General aviation experienced an average 7 percent growth because of increasing private business travel, and to a somewhat lesser extent, increased pleasure travel by an affluent and growing population.

Aircraft Technology: In the period 1975 to 2000, changes in aviation technology led to many significant improvements in aircraft. In general, aircraft exhibited significantly improved fuel efficiency and reduced noise levels. New aircraft types developed during this period included advanced supersonic transports introduced in 1990, 150-passenger jet STOL's in 1985, and a very large (1000-passenger) jumbo jet for passengers and cargo in 1985. In addition to these new air carrier aircraft, new business jet and general aviation turboprop and propeller-driven aircraft were introduced after 1985. The air carrier fleet mix continued to be dominated by types of aircraft similar to those in service before 1975 (two- and three-engine narrow-bodied jets). Throughout this period new aircraft types were being introduced to serve new and emerging markets, with the result that by the year 2000 many more different air-

craft types were in use than in 1975. The successful new vehicles included the jet STOL, which began to dominate short-haul intercity transportation in the 1990's; the extra-large jumbo, which was used as a charter-type aircraft for mass, long-range, low cost air travel, as well as for freight; and the SST, which served the limited, but lucrative, high speed, high fare international market.

Airports: To accommodate the steadily increasing level of aviation activity, major expansion of the national airport system was required in the 1980's and 1990's. Major new airports were completed after 1985 in several of the large hubs. New airports were also built in several of the medium and small hub cities. These new airports were made possible by changes in public attitudes toward airports, by airport planning to reduce environmental impacts, by controlling land use around airports, and by significantly improved airport access systems which allowed location of airports at greater distances from urban centers. STOL airports in urban centers proliferated during the 1990's; and local airports for feeder and communter service as well as special-purpose general aviation

AIR CARRIER FLEET MIX

	1970	1975	1980	1985	1990	1995	2000
4-ENGINE WIDE BODIED (747-TYPE)	1%	5%	7%	9%	10%	10%	10%
4-ENGINE NARROW BODIED (707-TYPE)	27%	22%	20%	10%	3%	0%	0%
2-3 ENGINE WIDE BODIED (DC-10 TYPE)	0%	6%	9%	12%	15%	17%	20%
2-3 ENGINE NARROW BODIED (727-TYPE)	58%	55%	51.2%	51%	49%	46.5%	41%
SMALL SHORT HAUL (50 PASSENGERS)	14%	12%	12%	15%	13%	11%	9%
S S T	0%	0%	.5%	1%	2%	2.5%	3%
4-ENGINE EXTRA LARGE (1000 PASSENGERS)	0%	0%	0%	1%	2%	3%	4%
JET STOL (150 PASSENGERS)	0%	0%	0%	1%	6%	10%	13%

The air carrier fleet grew from a total of 2,420 aircraft in 1970 to 3,890 in 1985 and 7,670 in 2000.

airports increased in number. Existing airports were reconfigured to increase their capacity for handling aircraft. Technological advances, such as control of wake vortices and improved air traffic control and landing systems permitted reduction in runway separation, leading to significant increases in airside capacity at existing airports by 1990. Airport congestion continued to be a significant problem at many airports, as increases in demand overwhelmed capacity improvements resulting from new capital investments and upgraded air traffic control. Airports used variable landing fees to shift cost-conscious traffic to less crowded periods.

Air Traffic Control: The rapid growth in aviation activity in this period necessitated accelerated improvement of the air traffic control system. Installation of the UG3RD was completed in the mid-80's and an airborne version of the 4th generation ATC system was in place in the 90's. Technological innovations emphasized increased flexibility for the pilot. These innovations shifted the focus of control from the ground to the air. Reduced aircraft spacing required special emphasis on the development of advanced collision avoidance systems and inertial navigation. On an economic level, the increased automation implicit in this system reduced ground-based labor costs; although in general, the air traffic control system found its costs steadily rising because of the increasing sophistication of the equipment required on controlled aircraft. Because of increasing demands on the Federal budget, the government began to look for ways to reduce its activity. In 1980, the Federal Government turned over operation of the air traffic control system to an independent quasi-governmental authority, the National Air Traffic Control Corporation. This COMSAT-like organization increased efficiency but found it difficult to control the increasing cost of air traffic control. The users of the system grew restless over rising ATC charges. As a result, the NATCC gradually shifted more and more of the burden of control to the individual pilot who could choose to invest in lower levels of avionics and fly only in segregated airspace. Accident rates were in fact declining rapidly, although the overall number of accidents, both for air carriers and general aviation remained higher than pre-1975 levels.

The Role of Government: The shift of goverenmental policy to deregulation and the encouragement of industrial initiative which arose during this period, led to radical changes in the structure and financing of Federal aviation activities. The Federal Aviation Administration, relieved of its responsibility in airport planning and financing, as well as its operational role in air traffic control, concentrated on its continued responsibilities in safety regulation and in research and development. Aviation taxes were significantly reduced with the abolition of all transportation trust funds. The passenger ticket tax was reduced from 8 percent to 2 percent, which still provided a surplus for general revenues. Charges for air traffic control services were directly levied by the quasi-public air traffic control corporation, and airports significantly increased landing fees, which became their principal source of income.

101

102

APPROACH

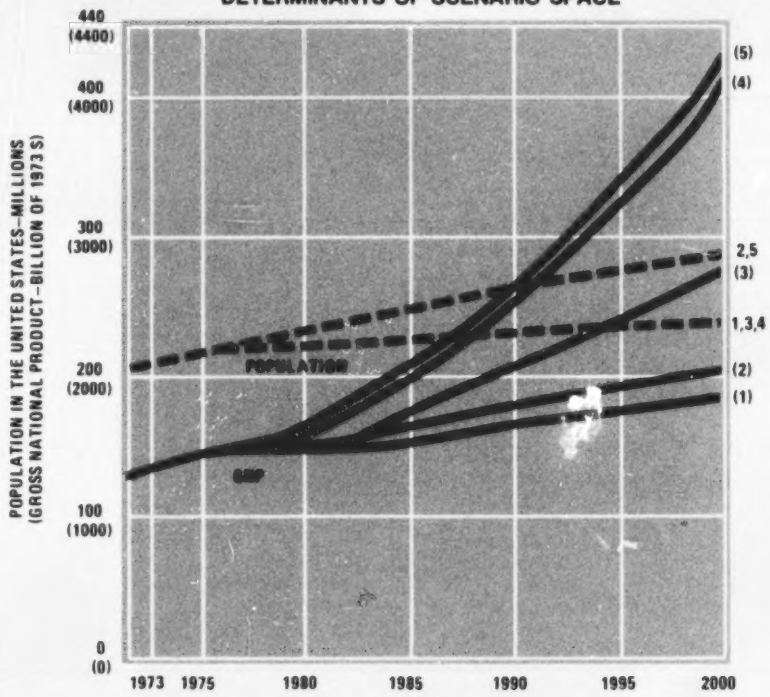
A. Phase I—World Scenarios

The use of future world scenarios as a policy development tool in the Federal Aviation Administration is based on one central assumption. The assumption is that of interrelationship. In the past air transportation and the National Aviation System (NAS) have grown as a function of the appearance of new technology. This study assumes that this relationship will continue but that the socioeconomic conditions of the world environment will also influence the form and characteristics of the future NAS. To illustrate this notion of interrelationship with a simple example, we might expect that a future increase in individual affluence would result in an increased propensity to travel, which would increase air travel and eventually the demand for service from the FAA navigation, information, and control facilities.

The approach to the development of the several world scenarios moved from this basic notion and began by identifying these relationships. First, the National Aviation System itself was defined by suitable quantifiable descriptors. Termed the key NAS variables, the descriptors include such system characteristics as aviation operations, stage lengths, enplaned passengers, FAA employees, trust fund revenues, business productivity, and others.

Next the study identified those socioeconomic variables that bear the closest relationship to conditions in the National Aviation System. Included in this category are such indicators as population, GNP per capita, wellhead price of crude oil, price of ferrous and nonferrous metal and other factors. The variations of GNP and population among the scenarios are shown below and the relationships between the NAS and the socioeconomic variables are summarized on the following page.

DETERMINANTS OF SCENARIO SPACE



Having identified the major relationships, the next step was to establish the "scenario space;" that is, a family of alternative futures that differ as a result of the initial conditions, and cover a plausible range of future conditions. To achieve this range, Gross National Product and population were assumed to have high and low growth rates in the resulting combination of four scenarios covering the scenario space.

KEY SOCIOECONOMIC VARIABLES	NAS VARIABLES: DIRECT OPERATING COSTS	INDIRECT OPERATING COSTS	DOMESTIC PASSENGER ENPLANEMENTS	AIR TAXI PASSENGER ENPLANEMENTS	INTERNATIONAL PASSENGER ENPLANEMENTS	DOMESTIC CARGO TONNAGE	INTERNATIONAL CARGO TONNAGE	GENERAL AVIATION OPERATION
POPULATION SIZE			0		0			0
POPULATION OVER 15			0		0			0
GROSS NATIONAL PRODUCT			X	X	X	X	X	X
DISPOSABLE PERSONAL INCOME	0	0	X	X	X	0	0	X
PERSONAL CONSUMPTION EXPENDITURE			X	X	X	0	0	X
LEISURE TIME (average work week, leisure expenditure)			X	X	X			X
UNEMPLOYMENT	X	0	0	0	0			0
MATERIALS COST (ferrous, non-ferrous metals)	X	0	0	0	0	0	0	X
BUSINESS PRODUCTIVITY	X	X	0	0	0	0	0	0
CRUDE OIL PRICES	X	0	0	0	0	0	0	X
INTERNATIONAL TRADE (food exports)			0		X	0	X	
ENVIRONMENTAL EXPENDITURES	X	0	0	0	0	0	0	X
MEDIAN EDUCATION			0	0	0			0

RELATIONSHIPS OF KEY SOCIOECONOMIC VARIABLES AND NAS VARIABLES

This table depicts the linkage that was considered to exist between the aviation variables and the socioeconomic variables. The X's represent direct linkage and the O's indicate an indirect linkage between these variables. For instance, it is felt that GNP has basically no effect on direct and indirect operations costs, but has a direct impact on enplanements, cargo tonnage and general aviation operations.

B. Judgmental Derivation

The world scenarios set the scene for description of the NAS, and the world descriptors within each scenario are used to calculate NAS parameter values. Certain important factors such as FAA policies, air transportation network structure, and competition from other modes are specified qualitatively with the aid of the world scenarios to provide both background and input for calculating NAS parameters. Then a set of key NAS variables is projected for each scenario using adjusted historic average annual rates of increase. The world descriptors are essential to adjustment of the projected historic trends of each variable. The key variables are direct and indirect operating costs, domestic and international enplaned passengers, air taxi enplanements, domestic and international cargo tonnage, and general aviation operations.

Then the forecasted values of the key NAS variables, the world descriptor values and historic data form the basis for projecting the values of internal aviation system variables. The variable parameters are average stage length, average seats per aircraft, average load factor, average utilization rates, and aircraft speed.

The final step is calculation of revenue passenger miles, aircraft operations, commercial miles flown, air carrier fleet mix and size, domestic cargo revenue ton miles, general aviation aircraft miles, fuel consumption, FAA employees and trust fund revenues, air carrier fatalities and accidents, general aviation accidents, total system noise and pollution, as well as congestion, pollution and noise at selected airports. This is accomplished with the aid of a series of submodels, or algorithms.

The entire process is repeated until internal consistency is achieved. The credibility of the results depends upon careful documentation of and factual basis for the applied judgment.

C. Check for Consistency

As a check on the validity of the forecasts using the judgmental approach, selected NAS variables are forecast with the aid of a computerized feedback model. The model forecasts air carrier fleet size, enplanements, load factor, revenue passenger miles, available seat miles, air carrier operating costs, air carrier operations, general aviation miles flown, and general aviation operations. A separate side model provides the necessary aircraft characteristic inputs to the main model.

This forecasting approach proceeds as follows:

a. An initial regression equation projects total intercity passenger miles in all modes as a function of the scenario world descriptors, population and GNP per capita for each scenario.

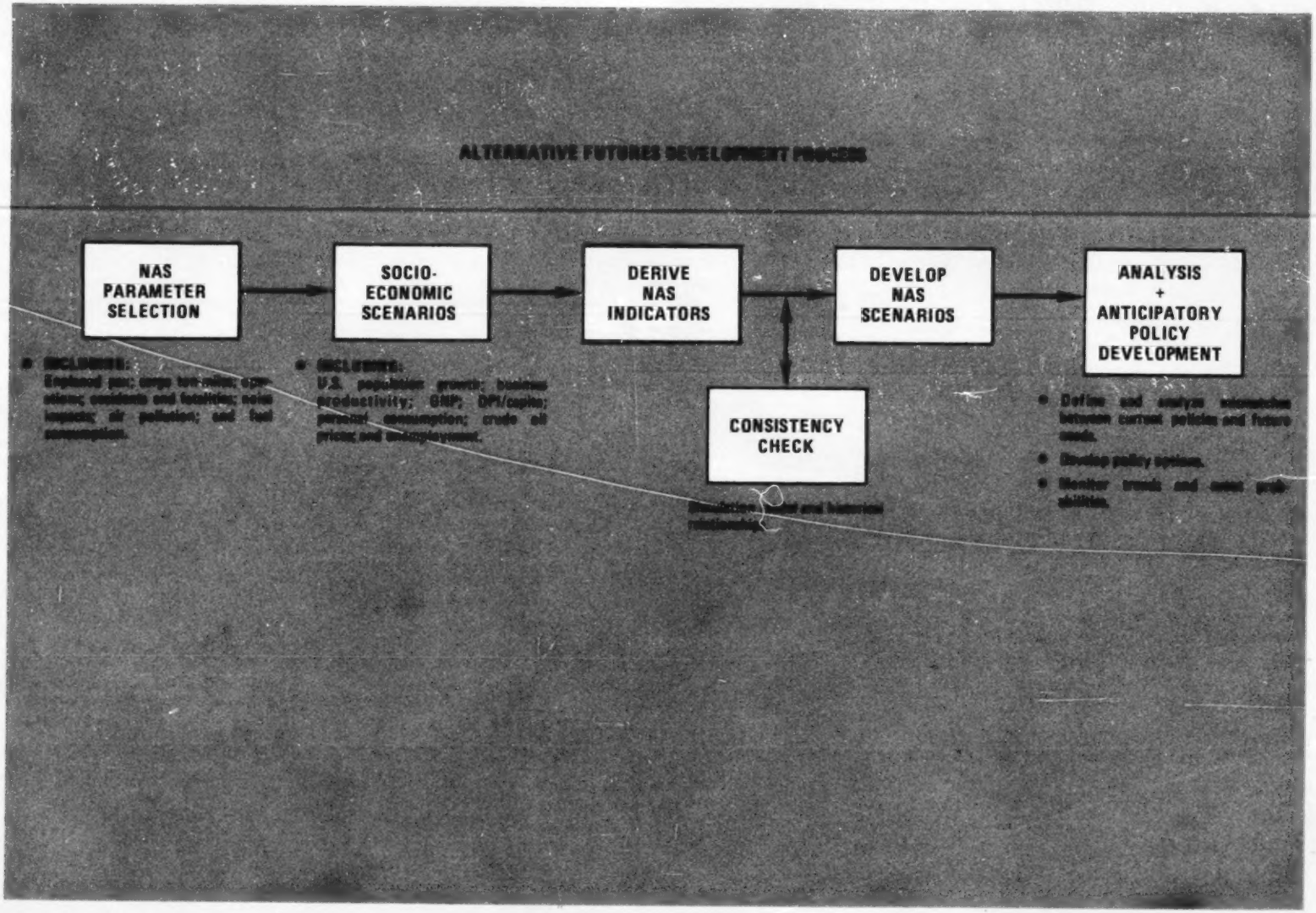
b. Adjusted intercity passenger miles are then apportioned in four travel categories, short-haul, long-haul, business and pleasure.

c. The adjusted intercity passenger miles figure for each travel category is then split among the air, auto, rail and bus modes on the basis of the cost, time, flexibility, comfort and convenience of the modes for the travel categories.

d. The resultant long-haul and short-haul air passenger miles then become determinants of air carrier size.

e. The above steps provide the necessary inputs for the specific forecast calculations.

The following flow diagram schematically depicts the process followed in developing and utilizing the alternative aviation scenarios discussed herein.


ALTERNATIVE FUTURES DEVELOPMENT PROCESS
NAS PARAMETER SELECTION
SOCIO-ECONOMIC SCENARIOS
DERIVE NAS INDICATORS
DEVELOP NAS SCENARIOS
ANALYSIS + ANTICIPATORY POLICY DEVELOPMENT
CONSISTENCY CHECK